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MAINTENANCE TRAINING SIMULATORS DESIGN AND ACQUISITION:

SUMMARY OF CURRENT PROCEDURES

By

George R. Purifoy, Jr.
Eugene W. Benson
Applied Science Associates, Inc.
Box 158
Valencia, Pennsylvania 16059

TECHNICAL TRAINING DIVISION
Lowry Air Force Base, Colorado 80230

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BROOKS AIR FORCE BASE, TEXAS 78235

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NOTICE

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This technical report has been reviewed and is approved for publication.

MARTY R. ROCKWAY, Technical Director
Technical Training Division

RONALD W. TERRY, Colonel, USAF
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This technical report is the first in a series that will explore the problems of maintenance training simulation design and acquisition. It is focused on the existing procedures followed by Air Force personnel in performing Instructional Systems Development (ISD) analyses to define maintenance training equipment requirements, and by System Program Office (SPO) Training Equipment Acquisition Managers in accomplishing training equipment procurement. Later reports in this series will structure appropriate functional specifications for the acquisition of maintenance training simulators, will present handbooks to guide ISD analysts in selecting appropriate types of maintenance training equipment and in designing and documenting required maintenance training simulator characteristics and features, and to guide SPO Acquisition Managers in preparing Prime Item Specifications.

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In this report both the ISD and SPO procedures are described as they are currently accomplished. Relevant documentation is cited and a comprehensive bibliography is included. For each of the two sets of procedures, a general decision model is presented as a reference, and general problem areas which appear to be degrading the ultimate cost-effectiveness of maintenance simulators are discussed.

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PREFACE

This report was prepared by Applied Science Associates, Inc. (ASA), Valencia, Pennsylvania, as an Interim Technical Report under Air Force Contract No. F33615-78-C-0019. Mr. George R. Purifoy, Jr. is the Principal Investigator and Project Director. The Air Force Human Resources Laboraboty (AFHRL), Technical Training Division, Lowry Air Force Base, Colorado, is the sponsor. Dr. Edgar A. Smith is the Project Engineer.

This study is one of a series of related studies under the Technical Training Division's Project 2361, Simulation for Maintenance Training. Project 2361 is an advanced development program to develop, demonstrate, test, and evaluate selected applications of computer-based simulation for Air Force maintenance training. The objective of this program is to build baseline knowledges about techniques, procedures, and principles necessary for broad applications of simulation in maintenance training. Simulator training devices are being fabricated and demonstrated in an operational training environment in order to establish cost, reliability, and training effectiveness information. These data will contribute to a determination of training value factors for eventual Air Force use. Demonstration of the training/cost-effectiveness of simulation techniques, coupled with analyses of effective simulation management tools, will provide the necessary empirical data to develop model specifications, design user handbooks, and to prepare life cycle management guides for the effective utilization of simulation in maintenance training.

Summarized in this report is the process currently in use by the Air Force to achieve design and acquisition of maintenance training simulators. Responsibilities for all portions of the process are defined, specific procedures followed by the Instructional Systems Development (ISD) team analysts in deriving training equipment design requirements, and by the System Project Office (SPO) Training Equipment Acquisition Manager in procurement are detailed, and existing problems related to training equipment acquisition are discussed.

The authors also wish to acknowledge the assistance and cooperation of the many individuals who contributed information and critiques ideas. From ASA: Dr. John Folley, William Pieper, and Thomas Elliott. From the Air Force:

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Capt. Richard Jeffries	ASD/SD24	"
Mr. Marty Bainbridge	ASD/SD24	" & Castle AFB
Lt. Col. John Rutledge	ASD/F-15 SPO	"
Major Ed Danber	ASD/F-16 SPO	"
Capt. Steve Johnson	ASD/ATC Resident Office and EF-111A SPO	"
Mr. Hilton D. Goldman	ATC/XPT	Randolph AFB
Capt. Gary Patterson	3700 TCHTW	Sheppard AFB
Lt. Col. Peter W. Stoughton	3306 TES/ATF	Edwards AFB
MSgt. Dennis Kox	"	"
SSgt. Al Behm	"	"
MSgt. Ed MacKay	"	"
TSgt. Bob Harrington	"	"
Mr. Forrest Wolferd	SAMSO/MNTP	Norton AFB
Major Ned Gow	4315 CCTS/CMC	Vandenberg AFB
Capt. Bernard Garfinkel	"	"
Capt. Bill Oakley	"	"
Maj. David G. Hamlin	3901 SMES/MBT	"
S/MSgt. Dale Lord	4200 TES	Castle AFB
TSgt. Steve McKinney	"	"
Major Daryle D. Cook	4017 CCTS	"
Capt. Bill Cole	FTD-533	Hill AFB
TSgt. Doug Farmer	"	"
TSgt. Sam Fulton	"	"

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SECTION I

INTRODUCTION

This technical report is the first in a series that will explore the problems of maintenance training simulation design and acquisition. It is focused on the existing procedures followed by Air Force personnel in performing Instructional Systems Development (ISD) analyses to define maintenance training equipment requirements, and by System Program Office (SPO) Training Equipment Acquisition Managers in accomplishing training equipment procurement. Later reports in this series will structure appropriate functional specifications for the acquisition of maintenance training simulators, will present handbooks to guide ISD analysts in selecting appropriate types of maintenance training equipment and in designing and documenting required maintenance training simulator characteristics and features, and to guide SPO Acquisition Managers in preparing Prime Item Specifications.

In this report both the ISD and SPO procedures are described as they are currently accomplished. Relevant documentation is cited and a comprehensive bibliography is appended. For each of the two sets of procedures a general decision model is presented as a reference, and general problem areas which appear to be degrading the ultimate cost-effectiveness of maintenance simulators are discussed.

The General Problem

Required maintenance capabilities for Air Force Weapon systems appear to be increasing as the sophistication of weapon systems increases. At the same time, training budgets are shrinking. These factors, and the relatively short post-training careers of a high percentage of Air Force maintenance personnel, make an increase in the cost-effectiveness of maintenance training essential. The use of simulators, as a major approach to maintenance training, is assuming growing importance as one thrust toward improvement. Simulation, long an established training technique for system operators, has a number of potential benefits when applied to the teaching of system maintenance. These benefits include reduced cost, increased training equipment reliability, instructionally effective device characteristics, student and instructor safety when practicing operationally hazardous activities, and the capability for tailored hands-on practice opportunities through malfunction insertion and the creation of operationally critical and seldom encountered conditions. However, the realization of these advantages has, to date, not been spectacular. There are no formalized procedures for maintenance simulator design. This has resulted in high variability in the cost-effectiveness of current maintenance simulators.

Definitions

Classes of Training Devices: This report adopted the training device classification developed by Kinkade and Wheaton[1] in which all "arrangements of equipment components, apparatus or materials which provide conditions that help trainees learn a task" are DEVICES. Devices are then sub-divided, as indicated in Figure 1, into TRAINING AIDS, which are used by instructors to present subject matter, and TRAINING EQUIPMENT, on which trainees practice job/task-related activities.

Simulator: A trainer which provides hands-on practice for aspects of the operational job which have been selected on the basis of their criticality and learning difficulty, with events/indications reproduced to the necessary degree of fidelity generally under computer control.

Simulation: The reproduction, in a training setting, of appropriate subsets (part task/whole task/integrated task) of performance opportunities which require the same combination of mental and physical skills, and the application of the same group of knowledges, as those required on the job.

Note that most, if not all, items of training equipment simulate; but that only a unique subset of them are defined as simulators.

[1] Kinkade, R. G., & Wheaton, G. R., Training device design. In H. P. Van Cott & R. G. Kinkade (eds.), Human engineering guide to equipment design. Washington, D.C.: American Institutes for Research, 1972.

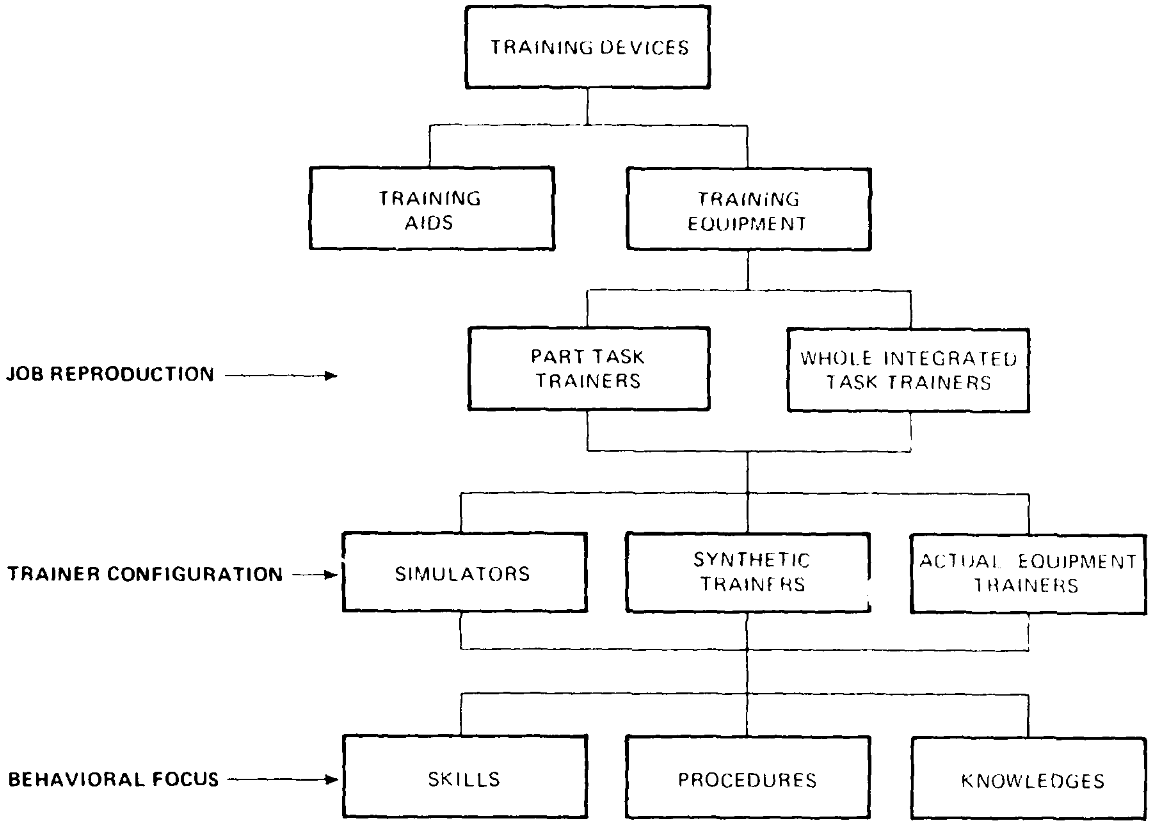

Figure 1. Classes of Training Devices

SECTION II

MAINTENANCE TRAINING EQUIPMENT PROCUREMENT PROCESS SUMMARY

This section is on overview of the process currently followed in acquiring maintenance training equipment. It provides a framework from which to discuss the specifics of the two major components of the acquisition process: the Instructional Systems Development (ISD) team activities, which are detailed in Section III; those of the System Program Office (SPO) Training Equipment Acquisition Manager which are described in Section IV.

AFHRL-TR-78-28, Description of the Air Force Maintenance Training Device Acquisition and Utilization Process, provides a relatively detailed and complete description of the total life cycle for maintenance training equipment. The life cycle can be divided into five phases:

Phase I - Identification of Requirements.

Phase II - Development of Specifications.

Phase III - Procurement.

Phase IV - Utilization and Support.

Phase V - Retirement.

The focus of the current study is on the first three of these phases. Phase I outlines the responsibilities of the ISD team. Phases II and III describe the responsibilities of the SPO Training Equipment Acquisition Manager.

Unfortunately, there is not a single and uniform procedure for designing and acquiring training equipment in the Air Force. By and large, each procurement, through various mixes of organizations, follows different procedures and results in different intermediate products (requirements, specifications, etc.). The following description only illustrates the major processes.

Phase I. Identification of Requirements

In Phase I, requirements for maintenance training equipment are developed by different organizations, depending primarily upon:

1. The acquisition mode or status of the system(s) to be supported -

   a. A new system (currently being procured through an Air Force Systems Commmand-SPO).

   b. A system out of acquisition (a current system for which Air Force Logistics Command has the program management responsibility).

   c. Several systems (requiring common or generalizable training support).

2. The locus of use for the training equipment -

   a. Mobile Training Sets (MTS) for Field Training Detachments (FTD).

   b. Resident Training Equipment (RTE) for Technical Training Centers (TTC).

   c. Training equipment for Strategic Air Command (SAC) training facilities. (SAC is noted as a separate locus of use because it maintains distinctive procedures including its own interpretation of ISD).

Table 1 summarizes the organizations having primary responsibility for establishing maintenance training equipment requirements for each acquisition mode and locus of use.

Table 1

Organizational Responsibility for
Training Equipment Requirements

LOCUS OF USE / ACQUISITION MODE	MTS FOR MAJOR WEAPON SYSTEMS	RTE & OTHER MTS	SAC TRAINING EQUIPMENT
New Systems	3306th T&ES[2]	Prime TTC	3901st SMES MBT
Systems Out of Acquisition	3306th T&ES[2]	Prime TTC	3901st SMES MBT
Several Systems		Prime TTC	3901st SMES MBT

Legend:

MTS	Mobile Training Set
T&ES	Test and Evaluation Squadron
RTE	Resident Training Equipment
TTC	Technical Training Center
SAC	Strategic Air Command
SMES/MBT	Strategic Evaluation Squadron

AFR 50-11, Training, Management and Utilization of Training Devices and AFR 50-8, Instructional Systems Development, specify that all training equipment requirements must be developed according to ISD procedures, and imply that such requirements evolve directly from the ISD process. Each of the three major requirement setting organizations listed in Table 1 does produce requirements for maintenance trainers, and yet each accomplishes them in a unique way. The ISD process does not provide a standardized procedure.

For new systems, requirement setting is initiated very early in the System Acquisition Life Cycle (SALC). General requirements for training equipment, based on the maintenance and training concepts established for the weapon system and on past experience, are initiated for the Statement of Operational Need (SON) long before the SPO and the ISD teams are formed. While these estimates are essential for long-range planning purposes, they are not based on definitive training analyses. This report recognizes that such training equipment requirement estimates are necessary from the initial concept stage of weapon system development forward through all of the developmental phases. However, until the ISD process is initiated the actual training requirements which should be supported by training equipment must remain speculative. While many benefits could be gained by improvements in methods for deriving early estimates of training and training equipment requirements, this study examines the acquisition

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[2]The 3306th T&ES supports test (AFR 80-14) programs and performs ISD as directed by HQ Air Training Command, including major modifications to weapon systems which are out of acquisition.

process from the point where the ISD team is established and training requirements based on formal analyses emerge.

Each of the three primary organizations responsible for conducting training and training equipment requirement analyses for new systems makes use of somewhat different data bases, information sources, technical resources, and analytical procedures. Each has different procedures and requirements for training analysis documentation and review. However, each organization identifies and lists maintenance tasks, and derives from them maintenance training and maintenance training equipment requirements.

The procedures followed to determine training needs for systems out of acquisition and for several systems are likewise different depending on which of the two organizations performs this function. There is no requirement that either of these procedures (unlike those governing new systems) follow formalized ISD or other systematic training equipment requirement analysis. Generally, new training equipment requirements for these systems come from the primary Technical Training Center and are identified by instructor personnel. Typically they are based upon a need to replace or upgrade existing training equipment which is damaged or obsolete, or they are based upon instructors' intuition about the types of training equipment which would enable them to be more effective. Many of these types of training equipment requirements are developed in coordination with a system contractor and are implemented through a contractor-initiated engineering change proposal (ECP). Such an ECP for a maintenance trainer is forwarded to various organizations for approval, including the 3901st SMES/MBT's maintenance training section, (the primary training evaluation organization for SAC, located at Vandenberg Air Force Base, California) where the recommendations are verified and the implications for the new maintenance trainer, in terms of its impact on organization, manning, and logistics, are reviewed.

Phase II. Development of Specifications

The output of Phase I, in whatever form it is prepared, is a statement of requirements for maintenance training equipment. Phase II translates these requirements into specifications appropriate for contractor design and fabrication. Procedures which structure the development of such specifications for maintenance simulators are currently uncertain, and are in a state of change within the Air Force. Only a few maintenance training simulators have been procured. Organizational responsibilities for the procurement process are only now emerging. The Simulator System Program Office (SIMSPO), ASD/SD24, Wright-Patterson Air Force Base, Ohio, will assume responsibility for any new maintenance simulators beyond those currently in procurement.

At the 3306th Test and Evaluation Squadron, Edwards Air Force Base, California, the ISD team provides the following training equipment requirements at the end of Phase I:

1. 3306 T&ES FORM 3 (TEST) Jan 79: A compilation of behavioral requirements for each appropriate trainer and/or training aid.

2. A proposed Course Chart.

3. A proposed Training Standard.

4. A draft functional specification modeled after the Prime Item Development Specification.

Training equipment requirements from the primary Technical Training Centers (TTCs) are provided on Form 601b, a requisition form used to justify the need for each item of required training equipment in terms of the Specialty Training Standard elements each will support, the associated number of students, and the number of hours of use anticipated.

Requirements from the 3901st SMES/MBT for SAC systems consist of ECPs prepared by the system contractor. These ECPs may be backed by a training requirements analysis, although to date formal ISD procedures have not been used. The ECPs specify desired changes for the missile system launch control complex which impact the simulator and/or other trainers.

After requirement approval by using command, ATC and the SPO, a Prime Item Development Specification is generated. Source selections, when necessary, are made usually in conjunction with ISD personnel and/or the using command originators of the requirements. Often, the primary weapon system contractor will also have the responsibility of complex trainers. In these instances, development and fabrication may be subcontracted.

During equipment design, a Preliminary Design Review (PDR), a final Critical Design Review (CDR), as well as formal and informal interaction between the contractor, the SPO, and the ultimate users, shape and approve the equipment configuration. Following CDR, contractual arrangements are made for equipment fabrication and, usually, evaluation.

Phase III. Procurement

Procurement procedures for maintenance training equipment are complex, intricate, and unstandardized. Table 2 summarizes various procurement responsibilities for different kinds of maintenance training equipment.

Table 2

Training Equipment Procurement Responsibility Summary

ACQUISITION CLASS* →	R&D REQUIRED		STANDARD AIR FORCE ITEM	CAN BE LOCALLY MANUFACTURED		AN AIRCRAFT	
ACQUISITION MODE ↓	AFSC ESD/ASD/SAMSO SIMSPO	AFLC	AFLC	ATC Technical Training Wing Training Equipment Branch	ACQUISITION COMMAND	ATC TTC	HQ USAF
New System or System Out of Acquisition or Several Systems	• Plans Statement of Operational Need (SON) (Originates with Using Command/ATC) Program Mgmt. Plan • Specifies • Funds (from AFSC) • Manages • Coordinates • Monitors for Design, Fabrication, Test & Evaluation	• Provides logistics support • Prepares to accept management responsibility	• Procures (Procedures depend upon item type) Communication Electronic Meteorological Automatic Data Processing Other • Funds • Issues to Using AF Activity	• Studies Feasibility • Designs (With ISD Personnel) • Fabricates	• Funds (ATC or Internal Facilities) • Develops and Fabricates	• Requests	• Approves • Substitutes

*NOTE An additional acquisition class is "Major Modification to Existing Equipment" requiring seldom used procedures from AFR 57-4 *Retrofit Configuration Changes*.

SECTION III

ISD PROCEDURES FOR TRAINING EQUIPMENT DESIGN

In this Section ISD as it relates to maintenance training equipment design requirements is discussed under three major headings:

1. The process and procedures currently used by the ISD Team at the 3306th T&ES.

2. A general ISD decision model leading to the identification and design of maintenance simulators.

3. Problem areas which appear to degrade the effectiveness of currently produced training equipment requirements.

The ISD Training Equipment Design Process

AFR 50-2, Instructional Systems Development, prescribes that the ISD process is to be applied to all training planning, including that done for new weapons systems. Techniques for general application are described in AFP 50-58, Handbook for Designers of Instructional Systems, Volumes I-V, and are taught by ATC principally in the Instructional System Designers course given by the 3700th Technical Training Wing, Sheppard AFB, Texas. In addition, there have been developed Interservice Procedures for ISD as well as numerous other versions of ISD tailored by specific civilian and military organizations to their individual needs and preferences.

In general, all of these ISD adaptions have in common a flow of analytical and developmental procedures which start with an analysis of the activities for which training is required and proceed to:

1. Determine training requirements.

2. Establish training objectives and their sequence.

3. Develop performance measurement techniques.

4. Select appropriate methods and media.

5. Develop instructional materials.

6. Conduct and evaluate the instructional program.

While the specific nature of the tasks themselves determines the particular characteristics of the developed curriculum and of the training equipment needed to provide necessary hands-on practice of the relevant tasks, the ISD approach used is basically the same for all applications for both new or existing systems as well as for I-Level or O-Level Tasks.

The 3306th T&ES is currently applying the Air Force organization ISD procedures to the development of maintenance training and training equipment for new systems. This organization has a core of highly experienced ISD team personnel and has evolved an adaptation of the general ISD model that has been singularly successsful in meeting Air Training Command/Air Force Systems Command (ATC/AFSC) requirements for new system maintenance training. Their ISD expertise is unique in the Air Force and their process is well documented.[3] For these reasons this Section reviews the procedures of the 3306th T&ES as they relate to the prescription of maintenance training and the design of maintenance training equipment.

Figure 2 illustrates the general relationships between the 3306th's ISD process and the procedural steps or phases outlined in both AFP 50-58 and the Interservice Procedures for Instructional Systems Development. The arrows in this figure connect each step or phase of the two cited ISD procedures to the most similar general step or specific procedure of the 14-step 3306th's process. Arrows crossing other arrows indicate activities which are done in different sequences in the two processes.

Interviews, in addition to those held with the 3306th T&ES on new systems, were held with ISD training development groups at a number of locations where production and upgrading of training for existing systems are done.[4] At none of these other locations was any "by the book" ISD analysis used in formulating requirements and/or designs for training equipment. Interviewees reported that formal ISD is generally done only for new systems. Factors influencing the use of less analytical methods for existing systems include:

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[3] 3306th Test and Evaluation Squadron, Mission Handbook, ATC, June 1979.

[4] See listing in PREFACE, page i.

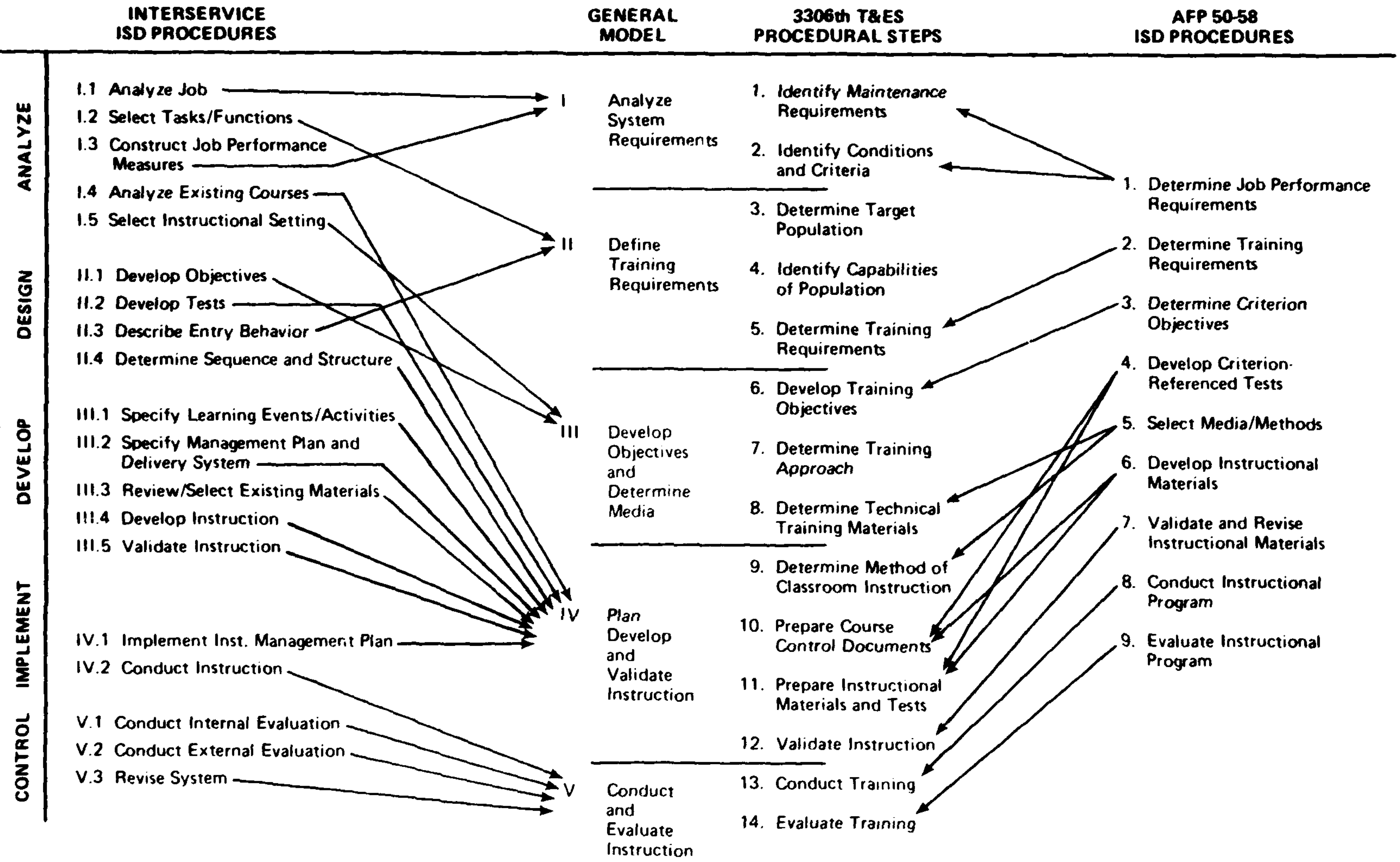


Figure 2. Major ISD Models and Their Relationships to the Procedures Used at the 3306th T&ES

1. Instructors' lack of ISD experience and training, and biases against formal analyses.

2. Insufficient time available for conducting formal analyses.

3. Lack of a comprehensive task data base.

4. Lack of formal ISD procedural guidance for developing training equipment.

Manning and Training of ISD Teams

The 3306th has a small cadre of experienced ISD analysts. Their assignments typically are new systems which are being developed in the "fly before buy" mode. Their involvement with these systems usually begins on or about the time a prototype is assigned to Edwards AFB for test and evaluation. At times, the 3306th becomes the location of ISD teams for systems not yet fully developed to the prototype stage and/or not assigned to Edwards AFB for testing. In all instances, personnel are assigned to the ISD team primarily on the basis of their selection as future instructors for the initial operational units; a small percentage is retained as squadron cadre. The operating philosophy is that it is more effective to select and train individuals to be ISD analysts who are already experienced instructors and Subject Matter Specialists (SMS) than it is to select experienced analysts and attempt to make of them systems specialists and competent instructors. The advantages of this approach include:

1. Experienced instructors generally make good analysts, since they bring to the ISD process first-hand experience with training and the knowledge of the types of training techniques which have worked for them most effectively in the past.

2. As SMSs, they can quickly learn the specifics of a new system and can better assure that all system-unique training requirements are included in the developmental process.

3. Experienced instructors are able to quickly learn appropriate ISD procedures. Without previous ISD training and experience, analysts do not come with entrenched ISD notions which differ from those found effective by the 3306th.

4. The 3306th T&ES has been able to tailor ISD training for incoming instructors to specific procedures that have been found to work best. By imposing strict documentation

requirements within the ISD procedure, the squadron achieves standardization in the developmental process and maximizes the traceability of training development decisions.

5. Instructors are able to take detailed knowledge of the system and of their own training materials with them when they go to the operational site. Consequently, they have the best possible preparation for fitting the course materials to the specific training situations they encounter and for making training course updates as the system evolves.

There are several disadvantages to these procedures:

1. A large portion of the trained and experienced SMSs leave the squadron when they assume their duties as the initial instructor personnel for a new operational system. This requires the squadron to replace and retrain new people for each new system.

2. While the squadron provides a tailored training regimen for incoming SMSs, actual practice in building the skills necessary for effective ISD occurs only on "their system." They are, thus, deprived of much systematic feedback which would enable the training equipment development decisions to be more effective during subsequent applications of the ISD process. It should be noted, however, that some senior squadron personnel have had extensive ISD experience with a number of previously analyzed systems.

3. SMSs new to the squadron tend to configure their individual training courses and the training equipment designs which they produce in ways that have been successful for them in the past. Thus, state-of-the-art training and training equipment techniques are often not employed because many instructors lack experience with or even knowledge of them.

ISD Procedures

The 3306th Mission Handbook previously referenced describes in detail all 14 of the procedural steps of their ISD process. These procedures define in greater detail the five phases of the general model shown in Figure 2. In the following portion of this report the application of these procedures is described in terms of the five phases of the general model.

In practice, the general model phases are seldom implemented in strict sequential order. Often analytic activities overlap. This is particularly true in the analysis of system requirements where additions and modifications to the general data base are often determined after the total ISD process is well along.

Step I. Analyze System Requirements. The basic task data base for many new systems is generally provided by the systems contractor. Systems designed prior to about mid 1977 were documented by a Task and Skill Analysis Report, illustrated by Figure 3. Typically, these data are in the form of a computer printout which essentially provides task and step names, and some very general information concerning task conditions, criteria for performance, and criticality. Later systems are documented by the contractor following Logistics Support Analysis (LSA) data formats. However, the computer printouts of LSA data are very difficult to read and to work with, and they currently cannot be selectively formatted by subsystem. As a result SMSs prefer to work from the hand written copies of the data input sheets. Three data formats are most often used:

1. Data Sheet C: Task Analysis Summary.

2. Data Sheet D: Maintenance and Operator Task Analysis.

3. Data Sheet E: Support and Test Equipment or Training Material Description and Justificaton.

Figures 4 and 5 illustrate the first and subsequent pages from Data Sheet D.

Seldom are any of these data bases complete. The SMS (analyst) must work with engineering drawings, contractor design personnel, Test Force personnel, and all existing technical data, as appropriate, to identify the specific tasks which make up the on-the-job performance requirements from which training will be derived. Often subsystems are in a state of evolution, making the identification and/or detailed description of both O- and I-Level tasks impractical. Additional tasks that are identified, and additional information describing task performance are recorded on the 3306 T&ES FORM 1 (TEST) as illustated in Figure 6.

Step II. Define Training Requirements. The using command for the new system should provide to the ISD team information about the Air Force Speciality Codes (AFSCs) of those who will become the new system trainees. Their previous weapon systems experience is also a needed input. This information is often not available when needed in the ISD process. As a result, the analysis must proceed initially on assumptions made by the SMS until they are verified or modified by both

ATC and the using command. Once the specific experience of proposed trainees is known (or assumed), training standards and SMS experience (or interviews with individuals experienced in the appropriate areas) provide the SMS with overall impressions of a profile of entry capabilities to which training must be geared. With this profile in mind, the SMS examines each step of each task and identifies those in which:

1. There is a knowledge or a skill new to the trainee.

2. Practice will be necessary to meet on-the-job performance requirements.

For each task or step meeting either or both of these criteria, there is assumed to be at least one training requirement. The 3306 T&ES FORM 2 (TEST) is used to document each task and all training requirements in terms of behaviors, teaching steps (groups of knowledges required for the learning of the primary steps), the conditions and criteria which delimit appropriate behavior, and an initial estimate of training time. Figure 7 illustrates the way in which FORM 2 is prepared. FORM 2b, Rationale Checklist, (Figure 8) is used as a guide to define training requirements and to structure additional information about each requirement.

Step III. Develop Objectives and Determine Media. In the process of filling out FORM 2, the SME must make judgments concerning situations which require stimuli in addition to the Instructor and Technical Orders. The situations are, in general, selected on the basis of instructor preference and insight, with the aid of a media analogram (shown in Figure 9 in the form of a decision table which represents the same set of decisions as does the logic flowchart-type analogram) and with the aid of the Rationale Checklist (Figure 8). Specific media within any of the defined classes are selected from instructor preference, from a more detailed listing of media in AFP 50-58, Volume IV, and/or from information about available training resources for the course under preparation.

Once all media have been identified in this way, the 3306 T&ES FORM 3 (TEST) is used to compile all behavioral requirements to be satisfied by each type of media which cannot be locally manufactured. The types of media for which a FORM 3 is prepared include:

1. Transparencies.

2. Slides.

3. Charts, diagrams, illustrations/drawings.

4. Models/cutaways.

GENERAL DYNAMICS CORPORATION
FORT WORTH DIVISION

CENTRAL DATA SYSTEMS CENTER
REPORT - FW3UACIWC1

06-24-77
PAGE 495

TASK AND SKILL ANALYSIS REPORT - *** F-16A EFF = ON ***

AFSC	FCN	TASK NO	EQUIPMENT TITLE	TASK TITLE	MAINTENANCE LEVEL	INTERVAL	FREQ / FH	ELAPSED TIME
326X2A	Y74BAOCO	01	PILOT'S DISPLAY UNIT, HUD SET	REMOVE AND REPLACE	O	UM	0.00882	000030

WUC	AF VAL. DATE	PERSONNEL ***AFSC	P/S	QTY***	SE NUMBER	SE NAME	SE QTY ***	TASK REL TECH ORDER
74BAC	000	326X2A	P	2				1F-16A-2-94JG-70-1

STEP NUMBER	STEP IDENTIFICATION	TASK CONDITIONS	TASK CRITERIA	CRITICALITY CODE
01	REMOVAL PROCEDURE:			
C2	DISENGAGE CIRCUIT BREAKER			S
03	REMOVE CAMERA FM DISPLAY			N
04	REMOVE ANGLE OF ATTACK INDEXER			N
C5	RMV NOSE WHEEL STEERING / AIR REF INDICATOR			N
06	LOOSEN RH / THEN LH CAPTIVE MT BOLT		SEQUENCE	S
07	LIFT DISPLAY FR MTG CRADLE		AVOID DAMAGE	S
08	INSTALLATION PROCEDURE			
C9	CLEAN MT GUIDE PINS / BOLT HOLES			S
1C	POSN HUD INTO MT CRADLE		AVOID DAMAGE	S
11	SECURE LH / THEN RH CAPTIVE MT BOLT		SEQUENCE	S

Figure 3. Sample of Contractor-Provided Task Data Base (Computer Printout)

DATA SHEET D: MAINTENANCE AND OPERATOR TASK ANALYSIS

Date 24 APRIL 78 Page 1 of 3

Submitted by REJB1 3637

GNDNBA000	ABXXØBA	TEL	14170		7BO424	
GNDNBA000		TEL				
GNDNBA000		767-552-1		14, 70767452	14170	
AGNDNBA000	ABXXØBA	SUALLY INSPECT TEL			2	

GNDNBA000	01 ØN TEL ELECTRONICS RACK, INSPECT ALL ACCESS DØØRS FØR
BGNDNBA000	PRØPER CLØSURE.
CGNDNBA000	02 ØN FWD LEFT SIDE ØF TEL ELECTRØNICS RACK, GAIN ACCESS

CONTINUED ON PAGE 2

GNDNBA000	01	462X0	.05	.05
BGNDNBA000	02	462X0	.05	.05
CGNDNBA000	03	462X0	.01	.01

CONTINUED ON PAGE 3

COMMENT			
	005DGNDNBA000		TØ TEL CØNTRØL PANEL.
	E	03	ØN RHT SIDE ØF TEL CØNTRØL PANEL, PUSH BATTERY ØN
	F		BUTTØN.
	G	04	ØN RHT SIDE ØF TEL CØNTRØL PANEL, PUSH PANEL PØWER
	H		ØN BUTTØN.
	I	05	ØN LEFT SIDE ØF TEL CØNTRØL PANEL, CHECK BATTERY
	J		CAPACITY GUAGE. IF BATTERY READING IS ØUT ØF THE
	K		ALLØWABLE RANGE, CHECK BATTERIES, REF LSA GNDNBA000
	L		TASK CØDE BBXXØAA.
	M	06	ØN LEFT SIDE ØF TEL CØNTRØL PANEL, CHECK GENERATØR
	N		FUEL TANK GUAGE (TANK 1 AND TANK 2). IF FUELING IS
	Ø		REQUIRED, REFUEL REFERENCE LSA GNDNBA000 TASK CØDE
	P		CGXXØAA.
	Q	07	ØN LEFT SIDE ØF TEL CØNTRØL PANEL, CHECK LAUNCHER
	R		TEMPERATURE GUAGE. IF TEMPERATURE READING IS ØUT ØF
	S		ALLØWABLE RANGE, PERFØRM ØPERATIONAL CHECK ØF THE
	T		ENVIRØNMENTAL SYSTEM REFERENCE LSA GNDNBA000 TASK
	U		CØDE BGXXØBE.
	V	08	ØN RIGHT SIDE ØF TEL CØNTRØL PANEL, CHECK LAUNCHER
	W		CØNTRØL LNCHER DØWN/DØWN LØCKED LIGHT. IF LIGHT IS
	X		ØUT, REFERENCE LSA GNDNBA000 TASK CØDE BG[illegible]ØBC FØR
	Y		ØPERATIØNAL CHECKØUT ØF ACTUATØR/DØWN LØCK.
	Z	09	ØN RHT SIDE ØF TEL CØNTRØL PANEL, PUSH PANEL PWR
	1		ØFF BUTTØN.
	2	10	ØN RHT SIDE ØF TEL CØNTRØL PANEL, PUSH BATTERY ØFF
	3		BUTTØN.
	4	[illegible]	ØN FWD LEFT SIDE ØF TEL ELECTRØNICS RACK, SECURE
	5		TEL CØNTRØL PANEL ACCESS DØØR.
	6	2	AT AFT END ØF TEL, INSPECT TIRES FØR PRØPER INFLATIØN
	7		PRESSURE. ADD AIR AS REQUIRED.
CONT ON PAGE 3	8	3	AT AFT END ØF TEL, INSPECT ALL TRAILER LIGHTS AND
	D059GNDNBA000		INDICATØRS FØR DAMAGE. REPLACE AS REQUIRED.

Standard Keypunch Worksheet
Form 5381 (4-66)

1. TASK NUMBER	2. TASK TITLE	3. PAGE 1 OF 1
[illegible]	Removal/Installation Pneumatic Ground Connectors	

4. AFSC	5. DATE	6. INFORMATION SOURCES AND DATE	7. ASSOCIATED WUCS
4. [illegible]	15 Nov 78	SME, TSgt Reecher, 15 Nov 78	

8 ACT #	9 [illegible]	10 ACTIVITY STEP IDENTIFICATION	11 ABNORMAL CONDITION	12 UNUSUAL CRITERIA	13 RESOURCES
1	X	Access to the two pneumatic ground connectors is gained through access doors [illegible] and [illegible]			Maintenance Stand
2	X	Tag throttle/thrust reverser lever	Tag to indicate maintenance is being performed	Warning: to prevent injury to personnel, do not start applicable pneumatic system until removal/installation procedures are completed	
3	X	Check that AP[illegible] [illegible] valve switch, located on flight engineer's panel, is in close position	Tag to indicate maintenance is being performed		
4		Cut safety wire on nipple to flange bolt			
5	X	Remove nipple			Strap wrench
6	X	Remove check valve			
7		Discard O Ring			
8		If installation is not to take place immediately, cover pneumatic ducting with suitable cover	To prevent entrance of foreign material		
9		Check threads of pneumatic fitting for burrs, crossthread, and foreign material			
10		Using new O Ring, install check valve and nipple	Make sure nipple bottoms against flange	Note: check valve is designed to prevent reverse installation in the flange	
11		Safety wire nipple to flange [illegible] with .032 inch [illegible] corrosion-resistant steel			
12	X	Remove tag from throttle/thrust reverser lever			
13	X	Remove tag from AP[illegible] [illegible] valve switch located on flight engineer's panel			
14	X	Check pneumatic ground connector for leakage by feel and sound on next APU or engine run up			
15	X	Close access doors [illegible] and [illegible]			

Figure 6. 3306 T&ES FORM 1 (TEST) Jan 79

1. TASK NUMBER	2. TASK TITLE			3. PAGE 1 OF
10-24-40-00-X-1	External Power Application (Main Receptacle)			

4. AFSC	5. ASST AFSC	6. CRITICALITY	7. TASK COMPLEXITY	8. DATE INITIATED	9. ASSOCIATED WUCs
325X0	43171F	ME CF SP SE N	SIMPLE COMPLEX	18 Aug 78	

10. SUBTASK TITLE	11. INFORMATION SOURCE AND DATE	12. TOTAL TIME
	Maint Manual Vol V, Oct 72	17 min

13. REQ	14. REF	15. BEHAVIORAL REQUIREMENT	15.a. BHV TYPE	16. ABNORMAL UNUSUAL CONDITION/CRITERIA	17. TTM/SE	18. METHOD	19. TIME
1-A	4A(1)	Locate Flight Engineer's Upper Instrument Panel No. 1	K		TP		2 min
2-A	4A(1)	Locate EXT PWR Switch	K		TP		1 min
3-A	4A(2)	Locate BAT Switch	K		TP		1 min
4-A	4A(3)	Locate Access Panel 124AB	K		TP		1 min
5-A	4A(3)	Locate Main Receptacle	K		TP		2 min
6-A	4A(3)	Locate EXT PWR NOT IN USE Light	K	Do not connect or disconnect external electrical power at airplane receptacle while supply unit is supplying power.	TP		1 min
7-A	4A(3)	Locate EXT PWR AVAILABLE Light (at main receptacle)	K		TP		1 min
8-A	4A(4)	Locate EXT PWR AVAILABLE Light (at Flt Eng Panel)	K		TP		1 min
9-A	4A(5)	Locate Cabin Ground Service Panel	K		TP		2 min
10-A	4A(5)	Locate EXT PWR AVAIL Light (Cabin Grnd Svc Panel)	K		TP		1 min
11-A	4A(6)	Locate VOLT/AMP/FREQ SEL Switch	K		TP		1 min

20. REMARKS

Figure 7. 3306 T&ES FORM 2 (TEST) Jan 79

RATIONALE CHECKLIST

TASK NUMBER:
10-28-22-00-X

This checklist will be annotated with a check mark for each behavioral requirement on the 3306 TES Form 2 (TEST) that will be satisfied by academic instruction to provide rationale for the training requirement.

REQUIREMENT NUMBERS

TRAINING REQUIREMENT	1	2	3	4	5	6	7	8							
1. New knowledge	✓	✓	✓	✓	✓	✓	✓	✓							
2. New skill			✓												
3. Practice required			✓				✓	✓							
4. Complex activity															
5. Condition/Criteria															
6. Unique manipulative skills															
7. New SE															
8. New special tools															
9. Is technical data available	✓	✓	✓	✓	✓	✓	✓	✓							
a. Instr clear & easily understood	✓	✓	✓	✓	✓	✓	✓	✓							
b. Oper steps in logical sequence	✓	✓	✓	✓	✓	✓	✓	✓							
c. Schematics adequate for detailed troubleshooting	✓	✓	✓	✓	✓	✓	✓	✓							
d. Sys units location identified	✓	✓	✓	✓	✓	✓	✓	✓							
TECHNICAL TRAINING MATERIALS (TTM)															
10. Is hands-on practice required			✓					✓							
11. Is air vehicle practical															
12. Is SE required															
13. Is actual equipment required															
14. Will audio only suffice															
15. Will static visual alone suffice	✓	✓		✓	✓	✓	✓								
16. Is static visual and audio sufficient															

Figure 8. 3306 T&ES FORM 2b (TEST) Jan 79
Rationale Checklist

5. Videotapes.

6. Trainers/simulators.

7. Actual equipment.

8. Audio.

	1	2	3	4	5	6	7	8	9	10
HANDS-ON PRACTICE REQUIRED	Y	Y	Y	Y	N	N	N	N	N	N
O-LEVEL TASK	Y	N	N	Y						
AIRCRAFT IS PRACTICAL	Y			N						
ACTUAL EQUIPMENT IS REQUIRED		Y	N							
AUDIO ONLY IS SUFFICIENT					Y	N	N	N	N	N
STATIC VISUAL ALONE IS SUFFICIENT						Y	Y	N	N	N
3-D REQUIRED						Y	N		Y	N
STATIC VISUAL & AUDIO IS SUFFICIENT								N	Y	Y
AIRCRAFT	X									
TRAINER			X	X						
ACTUAL EQUIPMENT		X								
AUDIO RECORDING					X					
MODEL/CUTAWAY + AUDIO RECORDING									X	
SOUND-SLIDE										X
VIDEO TAPES, FILM, ANIMATED PANEL								X		
GRAPHICS-PRINT							X			
MODEL/CUTAWAY						X				

Figure 9. Media Decision Table

A medium item which can be manufactured locally and will not require a monitored procurement, is not documented on the FORM 3. Figure 10 illustrates a typical FORM 3.

Each FORM 3 (one for each medium) must also include a description of the medium itself, its physical characteristics, its content, and its function. These descriptions are usually straightforward for all media, with the exception of major trainers. When the medium is a simulator or a major piece of complex training equipment, the

1. TTM/NOMENCLATURE	2. CONTROL NUMBER	3. DATE SUBMITTED TO TRRRM	4 PAGE 1 OF 1
External Missile Inspection Trainer	86-11-1	5. FINAL UPDATE	6.

7. AFSC	8. ASST AFSC	9 PREPARED BY/DATE	10. REVIEWED BY	11. APPROVAL
316X0T	None	SME, Shrum, 22 Nov 78		

12. TASK & REQ NUMBER	13. FORM 2 DATE	14. DESCRIPTION/BEHAVIORAL REQUIREMENT
		This trainer must have the same physical appearance (size and shape) as the AGM-86 missile with the capability of having the control surface lock set removed and installed. Also, the SIS safing pin and ADS safing pin with streamer must be installed. These switches must give the proper visual indications for the "safe" or "armed" conditions. The missile attach points and suspension lugs are required. No electronics is required, but the control surfaces should be realistic although they are not required to move. It would be desirable to have 10 defects built into the trainer's external features of which 5 exceed the rejection criteria standards.
86-11000-A-1-2-3	22 Nov 78	Inspect missile externally and determine the corrective action for the defects found.

Figure 10. 3306 T&ES FORM 3 (TEST) Jan 79

description on the FORM 3 is further defined and amplified by the preparation of a preliminary Functional Specification. In addition, identified media are often recorded on the SME log, (optional), with notations indicating those appropriate for local manufacture.

Step IV. Plan, Develop and Validate Instruction. Once training requirments and recommended training equipment have been established, the method of instruction is selected which is best suited to teaching the specific tasks. Tasks which generate training requirements are examined to identify categories of task-level training requirements, including:

1. Facts and definitions.
2. Concepts.
3. Principles.
4. Procedures.
5. Mental Skills.
6. Psychomotor Skills.
7. Attitudes.

Once task-level requirements are identified, a Teaching Methods Selection Grid (Figure 11), is used to select the most appropriate method for providing instruction on each task. Course control documents are prepared which include:

1. Course charts, which summarize the anticipated course in terms of major items of training equipment required and the segments of training content to be included (with associated training time estimates and any other information relevant to the course instructional design).

2. Course Training Standards, which list tasks, knowledges, and proficiency codes in the preferred teaching order.

3. Plan of Instruction (POI), which provides a relatively detailed description of the complete course by units of instruction, criterion objectives, required support materials and guidance, instructional unit duration, and appropriate Course Training Standard references. This POI becomes the lesson plan structure for the training course and is typically personalized by each instructor using specific annotations to cue appropriate in-class instructor and/or student activity.

AIC-450b

TEACHING METHODS SELECTION GRID

H - High Effectiveness
M - Medium Effectiveness
L - Low Effectiveness
NR - Not Recommended

+ - A Plus Factor for this Method
? - Depends on Circumstances
— - A Problem with this Method

	DEMONSTRATION/ PERFORMANCE	GUIDED DISCUSSION	LECTURE	PROGRAMMED INSTRUCTION			
TYPE OF OBJECTIVE							
FACTS AND DEFINITIONS	NR	NR	H	H			
CONCEPTS AND PRINCIPLES	NR	NR	H	H			
PROCEDURES	H	NR	M	H			
MENTAL SKILLS	H	NR	L	H			
PSYCHOMOTOR SKILLS	H	NR	NR	NR			
ATTITUDES	NR	H	M	NR			
FACTORS AND CONSTRAINTS							
MEETS INDIVIDUAL STUDENT DIFFERENCES?	+	+	-	+			
MAKES EFFICIENT USE OF INSTRUCTIONAL TIME?	+	-	+	+			
MANY STUDENTS, TOO FEW INSTRUCTORS RATIO?	-	-	+	+			
SPECIAL VISUAL AIDS AND MATERIALS REQUIRED?	-	+	?	-			
EASY TO UPDATE VISUAL AIDS AND MATERIALS?	?	+	?	-			
SPECIAL FACILITIES OR FURNITURE REQUIRED?	-	+	?	+			

Figure 11. Teaching Methods Selection Grid

Once a FORM 3 is prepared for each medium, a package of training equipment descriptive information is assembled for the Training Requirements Recommendation Review Meeting (TRRRM). The information package assembled includes:

1. 3306 T&ES FORM 3 (TEST).

2. Proposed Course Chart.

3. Proposed Course Training Standards.

4. Additional information as appropriate to substantiate recommended design (FORM 2s, etc.).

When the package involves a major trainer, such as a maintenance simulator, it will also include a preliminary Functional Specification, as previously described. The TRRRM reviews all training and training equipment recommendations from all of the SMSs on the ISD team and consolidates recommendations and equipment requirements to derive an optimum media package. When the package is approved by ATC, it is forwarded to the SPO for procurement.

Instructional materials are prepared following the prescriptions of the course control documents and utilizing criterion objectives derived from the analyses documented on 3306 T&ES FORM 2 (TEST). Performance and/or written tests are prepared for criterion objectives, as outlined in the POI. Instructional materials, consisting of Technical Orders, programmed text, study guides, workbooks, handouts, etc., are developed and integrated following the POI structure to form a cohesive and instructionally effective presentation. Materials are validated as they are prepared and refined prior to final course conduct.

<u>Step V. Conduct and Evaluate Instruction</u>. Although this step is listed as a part of the total ISD process, it typically is accomplished in a formal training environment at an operational site. Course conduct is provided by the SMSs who served as the ISD team and is done under the responsibility of the Field Training Group, Technical Training Center, or other management agency. Course materials are revised and updated as appropriate to improve their effectiveness and to reflect relevant system changes.

A Training Equipment Design Process Model

The preceding material has described the current Air Force ISD process for determining the need for and the characteristics of maintenance training equipment. In this section the underlying decision logic which should structure the process of proceeding from task information to simulator design characteristics, and of identifying the general classes of information which are required to support each decision set is explored. This approach of putting into sequence major sets of decisions provides a general training equipment design process model. The model is a general one in that decision sets are described at a level which generalizes across most of the training development situations in which the ISD process could result in maintenance training simulators.

The purpose of this design process model is to lay the groundwork for forthcoming hierarchical and associative relationships between information about tasks and appropriate training equipment characteristics and training applications by comparing it to currently used procedures. The model is an extension of existing ISD procedures and is intended to lead toward:

1. A determination of appropriate ISD procedure modifications which will cost-effectively support simulator development.

2. An identification of the procedural steps which can be effectively aided by having a reference manual (handbook) for procedural guidance and data.

3. The specification of the characteristics and specific content of appropriate ISD documentation of maintenance simulator training requirements.

A Decision Sequence

Given the procedural content and the intent of existing ISD guidance material, the following general decision areas begin at the point of determining what must be accomplished on the job and end by prescribing the best method of documenting the design as follows:

1. Determine the required job-relevant skills and knowledges.

2. Specify those skills and knowledges which must be learned by trainees (as contrasted to those which the trainee has already mastered from previous training and/or experience).

3. Identify those skills and knowledges which can be most effectively learned, at least in part, through practice on an item of training equipment.

4. Group skills and knowledges by class or type of training equipment.

5. Specify for each training equipment type how well the associated skills and knowledges must be learned.

6. Determine the order in which specific classes of training equipment should be employed to facilitate learning.

7. Establish design concepts which constitute preliminary descriptions of training equipment characteristics that seem to most effectively support specific learning requirements.

8. Develop a preliminary Plan of Instruction (POI) which integrates training equipment and all other appropriate media into an effective training scenario.

9. Revise and finalize the equipment design and detail all relevant functional characteristics to be utilized in the training scenario.

10. Document all equipment-related training requirements and associated training equipment functional characteristics as the principal input to the SPO acquistion process.

Figure 12 depicts this decision process and summarizes the principal informational inputs necessary to it.

Critical Features

The model represented in Figure 12 highlights a number of critical activities (decision sets) which influence the effectiveness of training equipment as it is ultimately employed in a training regimen. The model also suggests that criticality of these activities increases with training equipment complexity, since the potential is increased for inappropriate design to significantly affect training quality, and to have greater cost implications. Critical requirements for this decision model have been classified into four categories:

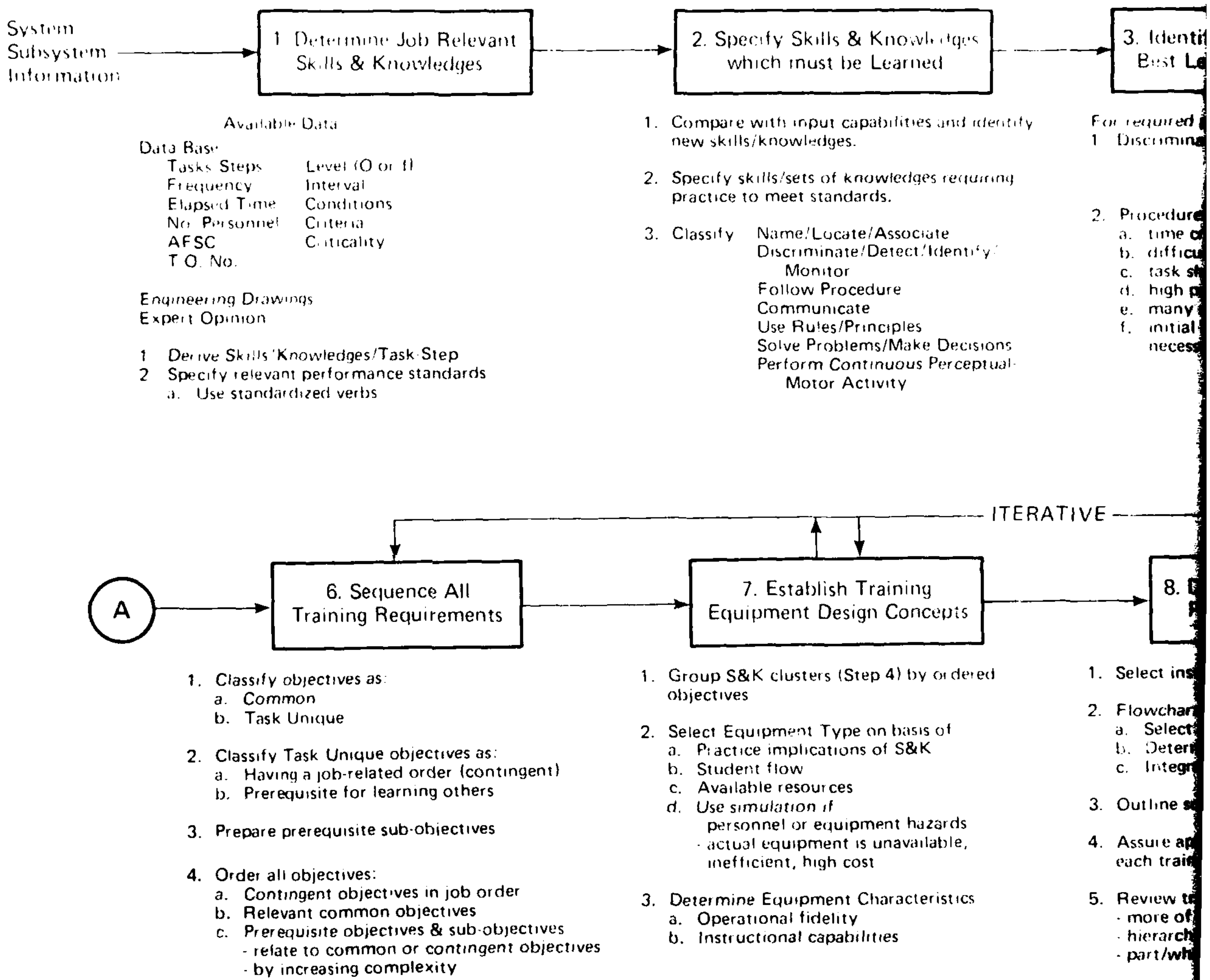


Figure 12. Decision Sequence for T

3 Identify Skills & Knowledges Best Learned on Equipment

For required practice
1 Discrimination of
   a dynamic cues
   b cues unique to hardware

2 Procedure following or Problem Solving if
   a time critical
   b difficult & high error consequence
   c task sharing
   d high psycomotor component
   e many alternatives
   f initial confidence (positive attitude) necessary

4 Group Skills & Knowledges by Training Equipment Class

1 Cluster by hardware S&K commonalities

2 Rank order
   a Within clusters by
      criticality
      frequency
      time to application
      learning difficulty
   b Between clusters by
      learning dependencies

3 Classify Clusters by
   a Learn knowledge & apply
   b Learn skills/task components
   c Learn whole task performance
   d Learn integrated task performance

5 Specify How Well Training Equipment Related Skills and Knowledges Must be Learned

→ A

1 Prepare Criterion Training Objective for T E clusters (AFP 50-58)
   a Conditions of performance
   b Performance activity (tasks/steps/activities)
   c Performance standard

2 Prepare Criterion Training Objectives for all other Skills and Knowledges from Step 2

ATIVE

8 Develop a Preliminary Plan of Instruction

1 Select instructional modules

2 Flowchart contest & presentation
   a Select strategies (methods)
   b Determine other appropriate media
   c Integrate Training Equipment

3 Outline scenario for student and instructor

4 Assure appropriate practice time student on each trainer

5 *Review trade-off relieve bottlenecks*
   more of same equipment
   hierarchy of equipment (fidelity)
   part/whole task division of TE objectives

9 Finalize Functional Equipment Characteristics

1 Review for
   a Learning effectiveness
   b Course continuity & flow
   c Equipment feasibility

2 Detail fidelity of
   a Functional requirements
   b Control/display relationships
   c Instructional features
   d Unique durability requirements
   e Programming requirements

3 Hypothesize alternatives

4 Cost analysis and comparison

10 Document Training Equipment Design

1 Physical appearance

2 Behavioral objectives

3 Functional characteristics
   a Controls
   b Displays
   c Components
   d Interactions
   } Fidelity Requirements

4 Instructional features
   a Cue feedback enhancement
   b Student/Instructor Stations
   c Time distortion capabilities
   d Measuring/scoring/recording capabilities
   e. Programming requirements

5 Training applications
   a Scenarios

...ence for Training Equipment Selection and Design

1. Task Analysis

a. The complete decision process represented by the model has as its foundation skills and knowledges derived from on-the-job performance requirements. These skills and knowledges, ideally, should be derived by those analysts most knowledgeable about the job performance requirement implications of various hardware designs; personnel subsystem specialists from the equipment contractor's workforce who prepare LSA data prior to the ISD effort. Even with this type of data input, opportunity must be provided in the ISD development schedule for Air Force SMSs to perform additional skill and knowledge derivation. Analogous skills and knowledges must also be available or derivable, for the anticipated trainee population.

b. Definitive task descriptive data required to support downstream decision-making. Categories which need to be added to the standard LSA data base (or to be more descriptively documented within existing data categories) include:

(1) Performance standards.

(2) The identification of tasks requiring major psychomotor skills.

(3) Tasks which must be done in conjunction with other tasks.

(4) Detail in the procedures for the selection of possible task alternatives (e.g., procedures to be followed in contingency situations or troubleshooting strategies appropriate to various symptom patterns).

c. Standardized task descriptive verbs are needed to increase the communication reliability of task and step descriptions, and to serve as the basis from which associative selections are made relating, for example, training equipment characteristics to types of maintenance tasks.

d. Criteria are needed to provide guidance for the realistic assessment of practice requirement implications related to various types of tasks and steps.

e. Criteria and guidance are necessary to promote accuracy and consistency in the classifications of skills and knowledges which form the basis for subsequent decisions relating to the selection and design of training equipment.

2. Training Development

a. ISD-compatible procedures are needed to encourage and structure the simultaneous design of training and trainers.

b. Useful and unambiguous criteria are needed to structure the selection of skills and knowledges which are appropriate for learning on training equipment, especially criteria which pinpoint those for which simulation is not only appropriate but essential.

c. A procedure is needed which guides the identification of the scope of training requirements which should be incorporated within any particular item of training equipment based upon an identification of the optimum order for meeting training objectives.

3. Training Equipment Characteristics

a. Bases and principles are needed to guide the making of training equipment tradeoffs (that is, the process of recognizing that various subsets of training objectives can be effectively realized by following more than one medium approach). Major classes of alternatives include:

(1) Selecting equipment which permit practice of fewer tasks or on part-tasks rather than incorporating whole tasks or integrated task practice.

(2) Changes in level of fidelity.

(3) Selection of a smaller subset of practice situations which are representative (generalizable) of those needed across any set of equipment-related training requirements.

b. Guidance is needed which describes types and techniques of simulation as they relate to the need for various types of practice situations.

c. Procedures and guidance are needed to effectively relate specific simulator training objectives and their associated skill and knowledge requirements to designs of both the operational characteristics to be simulated and the instructional features appropriate to optimum learning.

d. Guidance is needed in determining the appropriate computer generated/controlled aspects of maintenance simulation and the programming requirements which will yield appropriate degrees of flexibility in simulator employment and in determining in-house maintenance and updating of training exercises.

4. Functional Documentation

a. ISD team documentation specifications for describing training equipment (especially maintenance simulators) to initiate the SPO procurement process are needed.

Major Problem Areas

The preceding material of this section has summarized the ISD process currently in use in the Air Force. Overlayed on this process was a general decision model structuring the design and documentation of maintenance training equipment. Contrasting this general model with information about current Air Force ISD practices has highlighted six problems areas:

1. Lack of procedural documentation.

2. ISD not fully applied in this area.

3. A Priori simulator selection.

4. Insufficient ISD team training.

5. Required information not available.

6. Incomplete analyses.

These problem areas overlap and interact. For example, ISD analysts are not trained in certain areas simply because no formal procedures currently exist on which to base training. Each area is discussed here, however, to assist in conceptualizing solutions which have potential for improving the efficiency and the cost-effectiveness of the ISD process as it produces training equipment recommendations, particularly for maintenance simulation.

This classification of problem areas associated with the application of ISD procedures appears, at first blush, to be a heavy indictment. However, in reviewing the specific problems with each of these areas, it is important to maintain a realistic perspective. The ISD concept is relatively new, uniquely demanding, and not widely applied. Even so, its users, particularly the 3306th T&ES, have amassed an impressive record of effective training development and implementation. This classification of existing problems needs to be taken for what it is, an attempt to identify ways in which an already successful process can be further improved in the cost-effectiveness of its products.

Lack of Procedural Documentation

An extensive review has been made of the information requirements specified for ISD analyses in AFP 50-58, Volume II, Task Analysis, dated 15 July 1978. The descriptions in that volume constitute the primary procedural resource for ISD in the Air Force. The types, categories, and overall nature of the information requirements specified in AFP 50-58 for the ISD task analysis are both comprehensive in terms of the description it provides of tasks/activities and sufficient to provide the structure for all appropriate training and training equipment development decisions. Details of the information requirements and the task analytic procedures will not be repeated in this report. The headings from the task description worksheet used to collate and summarize data for the task analysis are presented in Figure 13 as a general summary.

Three major shortcomings characterize ISD documentation currently in use, including AFP 50-58 and all other ISD references previously cited:

1. They describe what is often an idealistic data availability situation. Much of the time the depth, accuracy, and reliability of task data available to the ISD analyst does not permit

PART 1

TASK DESCRIPTION WORKSHEET (EXAMPLE)

Page ______ of ______

Date ______ Analyst ______

System, Career Area, or Specialty Identification ______

Function or Duty ______

Task No ______ Name ______

Subtask No ______ Name ______

Info Sources ______

PART 2

GENERAL TRAINING FACTORS	TASK SPECIFIC TRAINING FACTORS
No Trained Personnel Required ______	Task Criticality ______
Qualifications of Target Population ______	% Performing the Task ______
Time Interval ______	No Performing the Task ______
Resource Availability	Frequency of Performance ______
Instructors ______	Learning Difficulty ______
Facilities ______	Training Development Time ______
Equipment ______	

PART 3 / **PART 4**

JPR Code	TASK/ACTIVITY DESCRIPTION: ACTION		INPUT(S)	OUTPUT(S)	SUPPORT INFORMATION	KNOWLEDGE			SKILL			KNOWLEDGE CODES
	Action and Item Acted Upon	Activity Support Elements: Equipment, Materials, Performance Aids	Action Determinant(s)	Proficiency Requirements	1 Assumptions 2 Rules, Definitions, Precautions, References 3 Contingencies 4 Remarks	Practice	No Practice	Proficiency Level	Practice	No Practice	Proficiency Level	A = Association C = Chain D = Discrimination CL = Classify RU = Rule Use PS = Problem Solving NOTES
TASK												
ACT												

Figure 13 General Summary - Headings from Task Description Worksheet

clean abstraction into the specified categories of the analysis procedure. Few suggestions are provided to assist the ISD team member in these situations.

2. The ISD guides and handbooks available are "principle" oriented and provide minimum guidance on the procedural or mechanistic application of these principles in making training and training device design decisions.

3. The nature of the decision-making required for ISD necessitates the learning, retention, and integration of a large number of complex concepts/constructs and associated knowledges. The procedures, in total, constitute a set of skill requirements which necessitates extensive practice for mastery. ISD, in its intended sense, cannot be conducted by individuals, no matter how well motivated and operationally knowledgeable, who have not had an opportunity for extensive practice and insightful feedback. The ISD process is neither mystical nor extremely difficult. However, it requires an ability to conceptually manipulate and dissect behavioral information. This is foreign to many teaching/training situations. It demands a degree of meticulousness and exhaustiveness with the minutiae of tasks and activities in order to make the same kinds of training decisions that are typically made with far less rigor.

ISD Not Fully Applied

The formal ISD process is not generally used when developing training equipment for systems out of acquisition or for common training requirements across several systems. Interviews with ISD groups working in these areas revealed several instances where the ATC mandate for the application of ISD to all training development was causing training development groups to prepare formalized training objectives for the training courses already being taught. While this exercise was useful in helping instructors to tighten their instructional regimens, it could have little effect on making the revised training more job-relevant. Since little task data in a formal sense exists for most of the systems out of acquisition, the preparation of training objectives can be based only on the training course as it exists, rather than on any formal set of job performance requirements. Similarly, the associated training equipment for existing courses was configured on the basis of instructor preference and tradition, rather than on the basis of any formal analytical derivation of simulation and instructional capabilities.

Job performance requirements and task analytical derivation of training requirements is the major key to the effectiveness of the ISD process. With older systems which have no extensive and systematic task data compilations, it remains impractical, in most instances, to devote the time and manpower required to amass such task data.

A Priori Simulator Selection

There is a growing emphasis within the maintenance training development community of the Air Force to consider the use of simulators as the primary training medium. While this emphasis forms a very strong vote of confidence for the maintenance simulation movement, it appears to reduce the already small inclination on the part of some ISD team members to examine alternative means for achieving maintenance requirements and for making cost-effective training and training equipment design decisions.

Unfortunately the ISD process as it currently exists provides little systematic guidance for the selection of specific types of training equipment. This gap in the ISD procedure increases the probability that training equipment selection will be based on preference rather than on formalized analyses aimed at maximizing cost-effectiveness. Under these conditions the uniqueness of a "simulator" may be easily justified for meeting training requirements which could as effectively be met by less costly approaches. To the credit of the 3306th T&ES, there have been a number of instances on recent new system ISD programs where simulators were not recommended. However, the emphasis remains.

Insufficient ISD Team Training

Selection of Training Equipment. AFP 50-58 provides little guidance in the selection of specific types of training equipment to support the achievement of specific training objectives. Numerous "considerations" are suggested, but little formal structure is available to make tradeoffs among all of the considerations, leaving the selection of trainers (from cardboard mockups to full-blown simulators) to the SME's preference--all of this within the broad limits imposed by the procedures for using the Media Decision Flow Chart or Decision Table.

A great deal of research over the years has shown that for any set of tasks to be trained, there are a number of alternative combinations of training media which can be employed to successfully achieve required learning. However, ISD team members are not trained to make media tradeoffs to achieve specific combinations of learning capabilities, and to maximize the efficiency of a training regimen.

Training equipment permits student practice of selected aspects of operational jobs, but seldom is the provision for practice sufficient by itself. It becomes effective only when integrated into a carefully orchestrated sequence of learning opportunities. It is this orchestration that is the key to effective training. Selection of specific training equipment must evolve from the design of the training regimen. Current training for ISD team members does not promote this process.

Design of Training Equipment Characteristics. Once the decision has been made to utilize a specific type of training equipment, a whole new set of training/learning implications becomes critical. These involve the design of the trainer itself. There are two general classes of decisions:

1. What aspects of the operational situation should be simulated, and in what ways?

2. What instructional features or capabilities, in addition to its simulation capabilities, should be built into the trainer?

Few SMSs prior to assignment to the 3306th T&ES have had the opportunity, especially in the maintenance training area, to participate in the design of a major trainer, and/or have the formal training in selectively employing the numerous state-of-the-art approaches to accomplish particular training strategies. For example, in the first category (concerning what should be simulated, and how) there are a large number of considerations dealing with level of fidelity, such as:

1. Environmental conditions.

2. Stimuli.

3. Response situations.

4. Control-display relationships.

In the second category (concerning what instructional features) there are decisions concerning when and how to employ:

1. Enhanced cueing/feedback.

2. Time distortion (freeze, accelerate, repeat).

3. Performance monitoring.

4. Student station.

5. Instructor station.

Currently, the ISD team members are not trained to deal with these issues in a formal way. Decisions initially reflect SMS experience and preference; later, when the equipment is in the procurement process, the contractor's human factors personnel may persuade the SMS to agree to some enhanced set of equipment characteristics. Despite the human factors input, the recommended characteristics are seldom derived from an integrated approach to meet the total set of training requirements.

Required Information Not Available

Traditionally, systematic training and training equipment development efforts, both pre-ISD and ISD, suffer from difference in time phasing between system development and training system development. This continues to be true even with the current ISD efforts on new systems being conducted in a "fly before buy" environment, where the formal ISD effort is not initiated until the prototype hardware is undergoing test and evaluation. Three major classes of information currently appear to impede ISD progress early in the analytical phase:

1. Maintenance and training concepts. Even though the SON should identify both maintenance and training concepts which will be implemented on a new system, confirmation and commitment to those concepts are at times, difficult for the SMSs to obtain. As a result the ISD team must intitially make assumptions about the ultimate maintenance organization and hierarchy of training experiences which will prepare people for field maintenance assignments.

2. Trainee (target) population, including levels and AFSCs. There are often difficulties in obtaining using command commitments for target populations relevant to various system maintenance requirements. One consequence of this inability to identify the specific target population early in the ISD process is that assumptions are made about the specific AFSCs and levels to be assigned. More importantly, assumptions are made about the recent weapon system experience which the target population will have as they enter training. The training requirements themselves are based upon the SMS's judgment of new

skill and knowledge requirements. Thus an erroneous assumption about trainee previous experience can produce a mismatch between the job performance requirements for the new system and the total set of skills and knowledges which the training program is designed to generate.

3. Comprehensive task data. The task data base for new systems is generally produced by the system contractor. However, the system in its prototype phase typically does not have a complete and validated data base. Often subsystems are in a state of evolution, making the identification and description of both O- and I-Level tasks difficult.

There are no ideal solutions to any of these three major information area problems. Critical implications of them are: (1) the ISD team as a whole needs to very carefully coordinate their needs in order to encourage and promote timely decision-making at the SPO, the using command, and ATC, and (2) assumptions need to be made early in the ISD process, documented, and approved/modified as information becomes available. For existing systems, ISD teams need to "bite the bullet" and quickly generate relevant task data prior to making major training and training equipment decisions.

Incomplete Analyses

The key to job-relevant and training-effective ISD is comprehensive task analysis information. It consists of the specific skills and knowledges which must be a part of the job incumbent's repertoire for successful on-the-job performance. To obtain skills and knowledges, the task descriptions (the names of specific tasks and steps, a description of the conditions affecting performance, and a specification of relevant performance standards) are analyzed to identify the specific behaviors needed (skills and the application of sets of knowledges). The behaviors judged new to the trainee are recorded as training requirements and are further analyzed to generate training course and training equipment implications. AFP 50-58 describes this process in varying detail. In actual use, however, these procedures suffer at three major points:

1. <u>Task and Skill Analysis</u>. Figures 3 and 6 in the preceding subsection of this report illustrate the typical contractor computerized data base (LSA) and a completed FORM 1 which record relevant tasks not found in the LSA data base; (on some systems there are no contractor produced data and all task

information is recorded on the FORM 1). The two forms, together, constitute the typical working data base for the ISD team on a new system. The problem is that this data base consists of task descriptions, but not detailed task analysis. Required skills and specific knowledges are not identified. The procedure, however, is to use the SMS's knowledge of similar systems and to do the analysis "in head." For any step or any task in which a new skill or knowledge is identified, the SMS prepares an entry on the FORM 2. The Rationale Checklist is used to document each of these decisions, however, it does not identify the specific skills and/or knowledges involved.

The 3306th T&ES procedures specify that behavioral requirements in the form of skills and knowledges for training requirements be identified on the FORM 2. However, the FORM 2 often uses the same task descriptive wording as the FORM 1 for each step where training requirements are judged to exist, (the more experienced the SMS the more likely that the ciritical behaviors will be comprehensively identified). If the step is to remove Part A, then the "behavioral requirement" on the FORM 2 will many times be "remove Part A." If the removal is associated with risk of equipment damage, the "condition" column of the FORM 1 might caution "avoid damage." On the FORM 2, the identical "avoid damage" wording will also be recorded, without specifying the particular activities which should be followed to avoid damage. For SMSs who are completely familiar with a particular step of a specific task (a condition which might be unlikely in a new system), the "avoid damage" caution might be sufficient to induce appropriate recall, so that the specific skills and knowledges implied are given appropriate consideration in the remaining portions of the analysis. It is possible, however, that in complex subsystems some important skills and knowledges may be overlooked.

2. Training Equipment Selection. There are several problem areas associated with the selection of training equipment to be utilized in any of the subsystem maintenance training programs for new systems. First, media selection is generally derived

from the Media Checklist and on personal preference, and is prescribed to meet specific training objectives. For training equipment this procedure often results in all identified training requirements judged appropriate for practice being assigned to a major simulator, with various audiovisual media in support. The procedure does not guide decisions concerning the use of other types of practice devices, including part-task trainers, procedures trainers, etc. Similarly, the procedure does not facilitate decisions about what set of total practice requirements should be incorporated in the simulator; two or more simulators having limited application might prove to be more cost-effective in a given training situation than one major all-encompassing simulator.

Second, media selections are made and documented prior to the generation of a POI which defines the sequence and appropriate strategies for achieving specific training requirements. Thus, often, the POI is built around the selected media rather than the media selected to most cost-effectively support an optimum instructional regimen.

3. <u>Maintenance Simulator Design</u>. The operating characteristics of a maintenance simulator are currently selected, primarily, on the basis of the operating charateristics of the equipment itself. To paraphrase one SMS, "I'm not interested in exotic features like providing knowledge of results. I only need the simulator to behave like the airplane, and I can teach with it." Consequently, most simulator design recommendations which come from an ISD team to the SPO (through the TRRRM and ATC review process) essentially duplicate actual equipment operation. This is not necessarily bad, but it significantly reduces the probability that maximum training usefulness can be derived from the device.

While it is easy to criticize the current simulator design process, there are not as yet ISD procedures which can systematically produce training devices with improved cost-effectiveness.

SECTION IV

THE SPO TRAINING EQUIPMENT ACQUISITION PROCESS

The System Program Office (SPO) involvement with the training equipment acquisition process is described in this Section under three main topics:

1. Processes and procedures currently employed.

2. A general model that sequences acquisition decision sets.

3. Major problem areas.

Processes and Procedures

The current processes for procuring maintenance training equipment do not fit into a single pattern. Each weapon system SPO is differently organized to suit its functional needs. This results in training equipment management assigned to the Special Projects Office of one SPO, to Logistics in another SPO, Development and Operations in a third, etc.

Broad categories of activities of Training Equipment Acquisition Managers, however, are common to all SPOs. The activities for which the manager is responsible include:

1. Validation of training device requirements as presented by ATC, resulting from the ISD process.

2. Validation of the weapon system contractor's engineering data.

3. Preparation of procurement documentation which translate ISD-derived training equipment design requirements into equipment functional specifications. The training device acquisition goal is to provide no more or no less than the projected system requirements.

4. Management of contracting procedures from contractor source selection through monitoring the development process to assure that a training-effective product is delivered on time.

Validation of Training Device Requirements

The SPO Acquisition Manager's familiarization with the analytic activities leading to the ISD team specification of training equipment design requirements provides a firm basis for review and validation of the requirements in light of total weapon system procurement constraints. In addition, requirements are further defined by:

1. ATC inputs to the Initial Program Management Plan that summarize required personnel training, and assure that training considerations have been inserted wherever applicable.

2. ATC inputs to the training equipment contractor's statement of work.

3. ATC participation in the source selection process.

4. Frequent briefing of the SPO Acquistion Manager by the ISD team related to the training equipment derivation process.

When the finalized training equipment requirements from the ISD team are formally presented, the SPO Acquisition Manager who has kept current with the ISD process is not confronted with surprises. He can then realistically assess the appropriateness of or the need for device requirements in light of the personnel qualifications necessary to maintain the weapon system.

Validation of Engineering Data and Preparation of Procurement Specification

Engineering feasibility of training equipment must be given attention in consonance with estimated effectiveness, cost, and operational time constraints.

Other tasks which contribute to both the validation of device training descriptions and the translation of them into procurement specifications involve establishing:

1. The degree of required functional fidelity.

2. The extent to which the device will facilitate learning of required motor and or cognitive skills.

3. Fault insertion capability.

4. Ease for future updating or modification.

5. Requirements for device reliability and maintainability.

6. Safety requirements.

7. Requirements for appropriate structural ruggedness, considering the probable nature and frequency of student use and misuse.

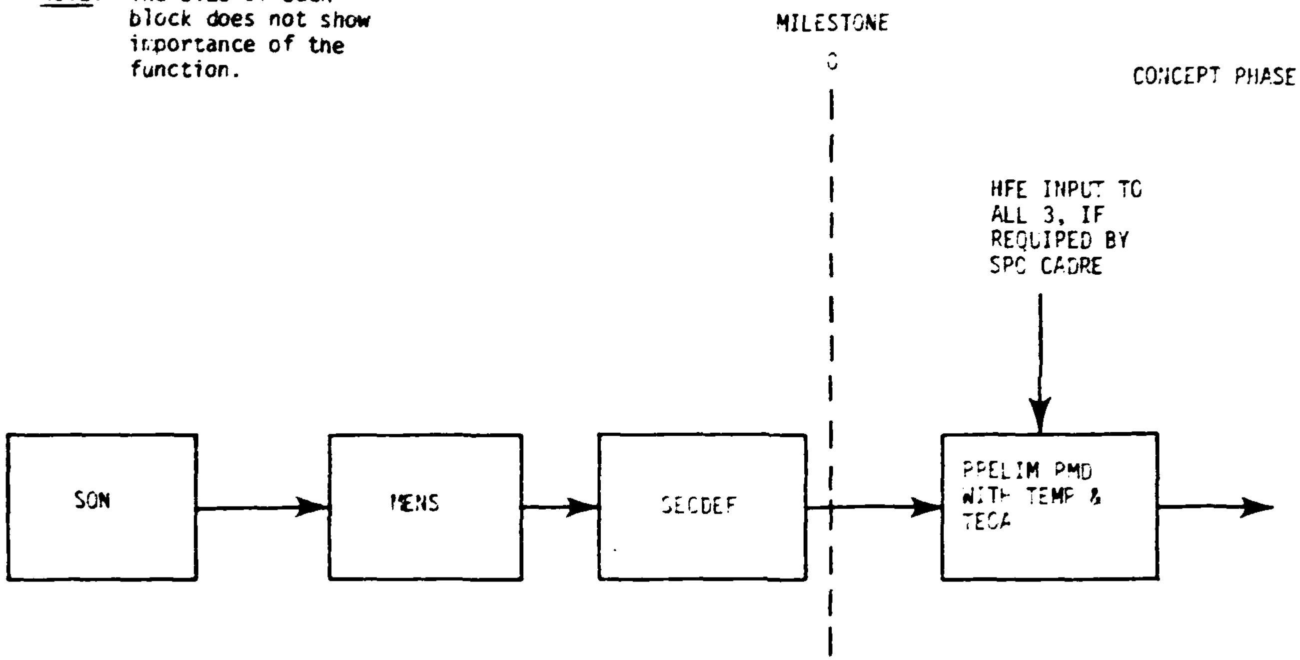
Available Resources

The Training Equipment Acquisition Manager in the SPO must arrange for and coordinate activities of advisory sources which can aid him in making training equipment decisions. The major advisory resources available include:

1. The Engineering Directorate. Experienced engineering experts and training equipment specialists work either full time for the SPO Acquisition Managers or are committed to the program for a specified percentage of their time, depending on the specified needs of the SPO as justified to the Engineering Directorate. The training equipment specialists participate from early in the definition phase through the validation of device functional requirements. This participation entails preparing procurement specifications, contractor source selection, developmental monitoring, and product testing. Engineering psychologists of the Human Factors Branch, Engineering Directorate, are also assigned to SPOs in the same manner. Figure 14 depicts Engineering contributions to system acquisition.

2. Air Force Laboratories. These Laboratories provide advisory resources, to the limit of manpower availability, on request from the SPO. Training psychologists from the Air Force Human Resources Laboratories (AFHRL) at Lowry AFB, Colorado, and Wright Patterson AFB, Ohio, make contributions to all phases of the maintenance training equipment acquisition process. Engineering personnel

NOTE: The size of each block does not show importance of the function.

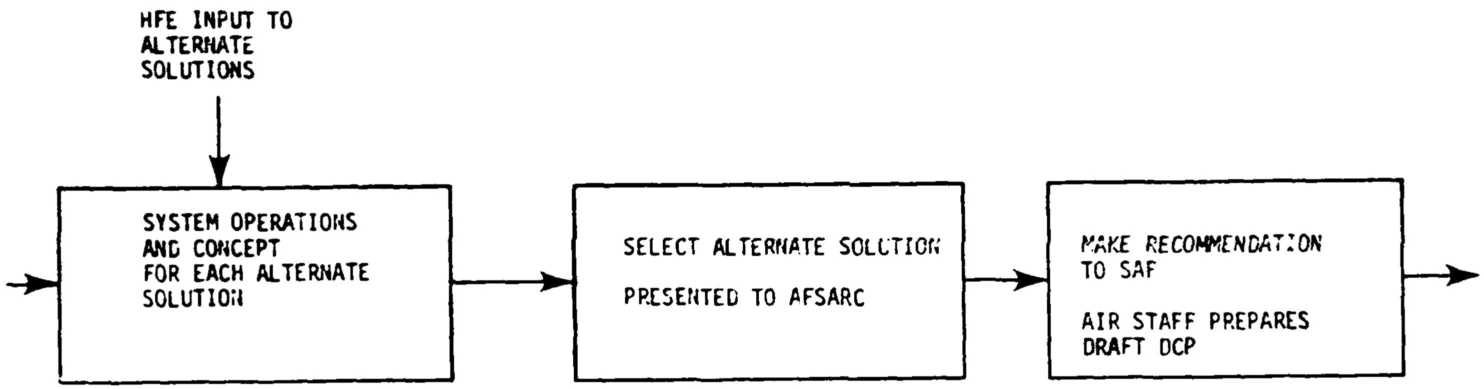


LEGEND

SON - STATEMENT OF OPERATIONAL NEED
MENS - MISSION ELEMENT NEED STATEMENT
SECDEF - SECRETARY OF DEFENSE
HFE - HUMAN FACTORS ENGINEERING
TEMP - TEST & EVALUATION MASTER PLAN
TEOA - TEST & EVALUATION OBJECTIVES ANNEX
PMD - PROGRAM MANAGEMENT DIRECTIVE

Figure 14. Flow Chart Depicting Engineering Contributions to System Acquisition

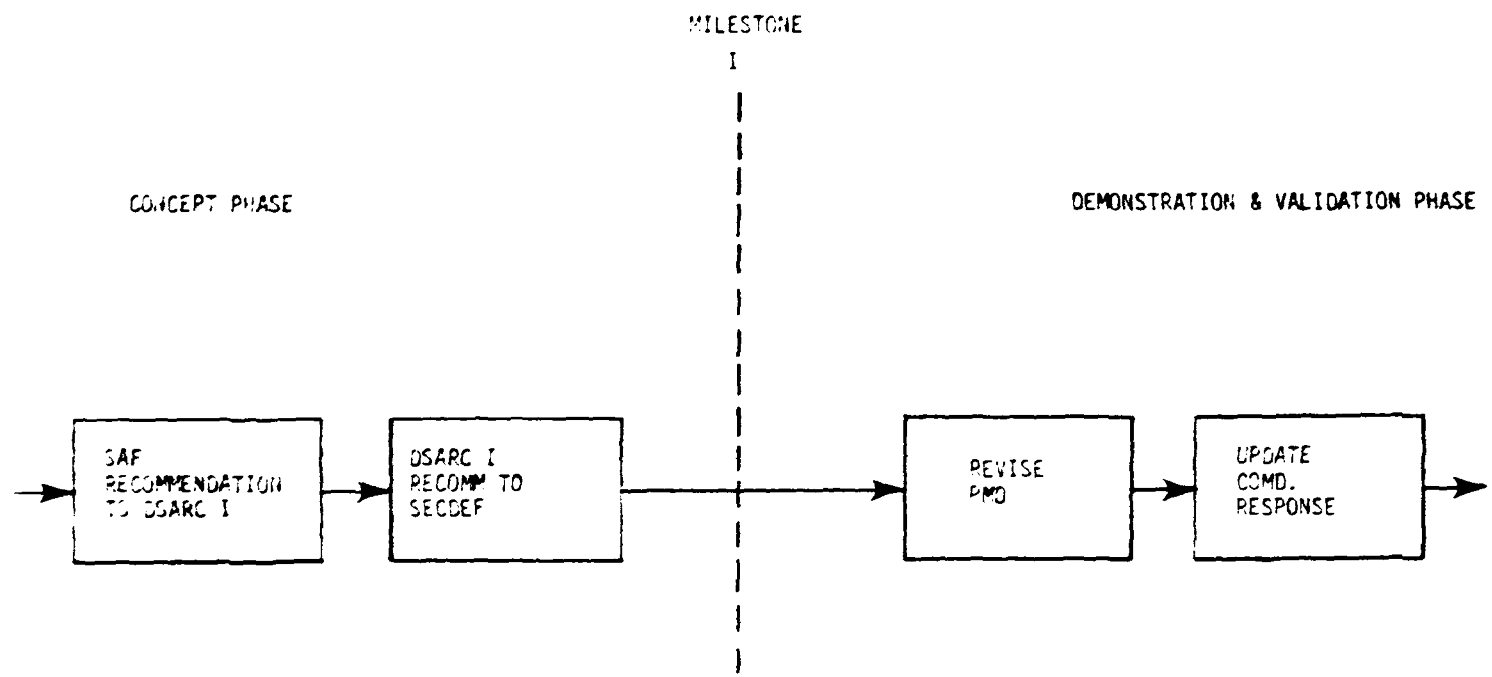
CONCEPT PHASE



LEGEND

HFE	-	HUMAN FACTORS ENGINEER
AF	-	AIR FORCE
SYS	-	SYSTEM
ACQ	-	ACQUISITION
AFSARC	-	AIR FORCE SYSTEM ACQUISITION REVIEW COUNCIL
SAF	-	SECRETARY OF AIR FORCE
DCP	-	DECISION COORDINATION PAPER

Figure 14. (Continued)

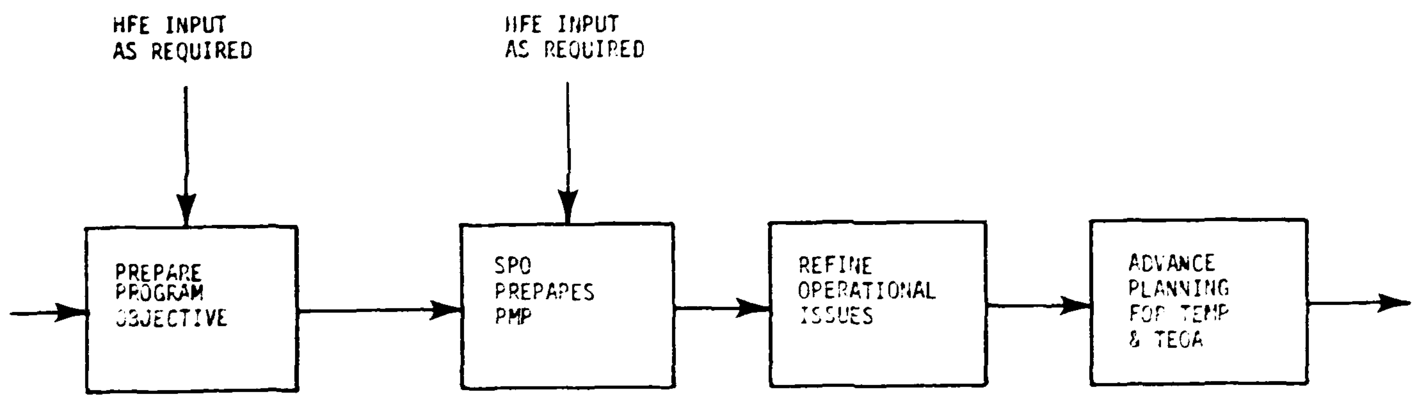


LEGEND

SAF - SECRETARY OF AIR FORCE
DSARC - DEFENSE SYSTEM ACQUISITION REVIEW COUNCIL
SECDEF - SECRETARY OF DEFENSE
PMD - PROGRAM MANAGEMENT DIRECTIVE
COMD - COMMAND

Figure 14. (Continued)

DEMONSTRATION & VALIDATION PHASE

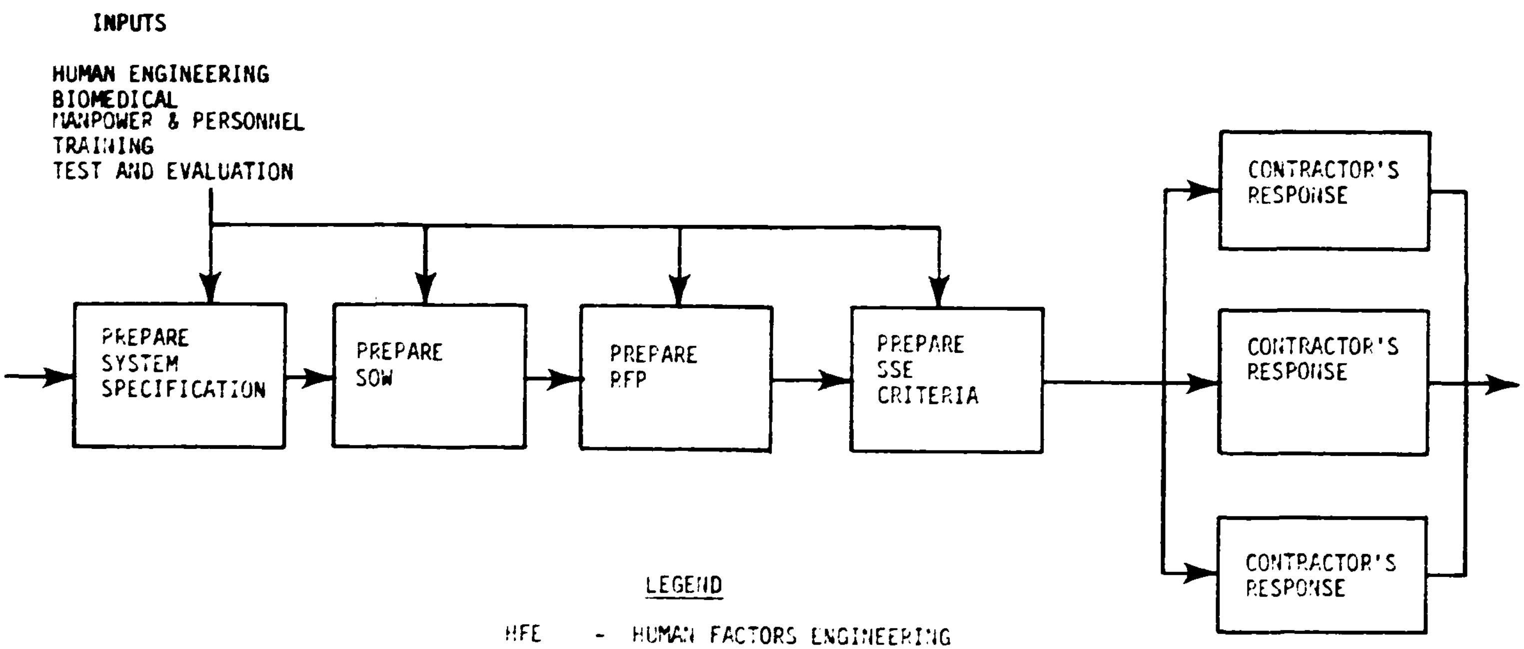


LEGEND

HFE - HUMAN FACTORS ENGINEER
SPO - SYSTEM PROGRAM OFFICE OR OFFICER
PMP - PROGRAM MANAGEMENT PLAN
TEMP - TEST EVALUATION MASTER PLAN
TEOA - TEST EVALUATION OBJECTIVES ANNEX

Figure 14. (Continued)

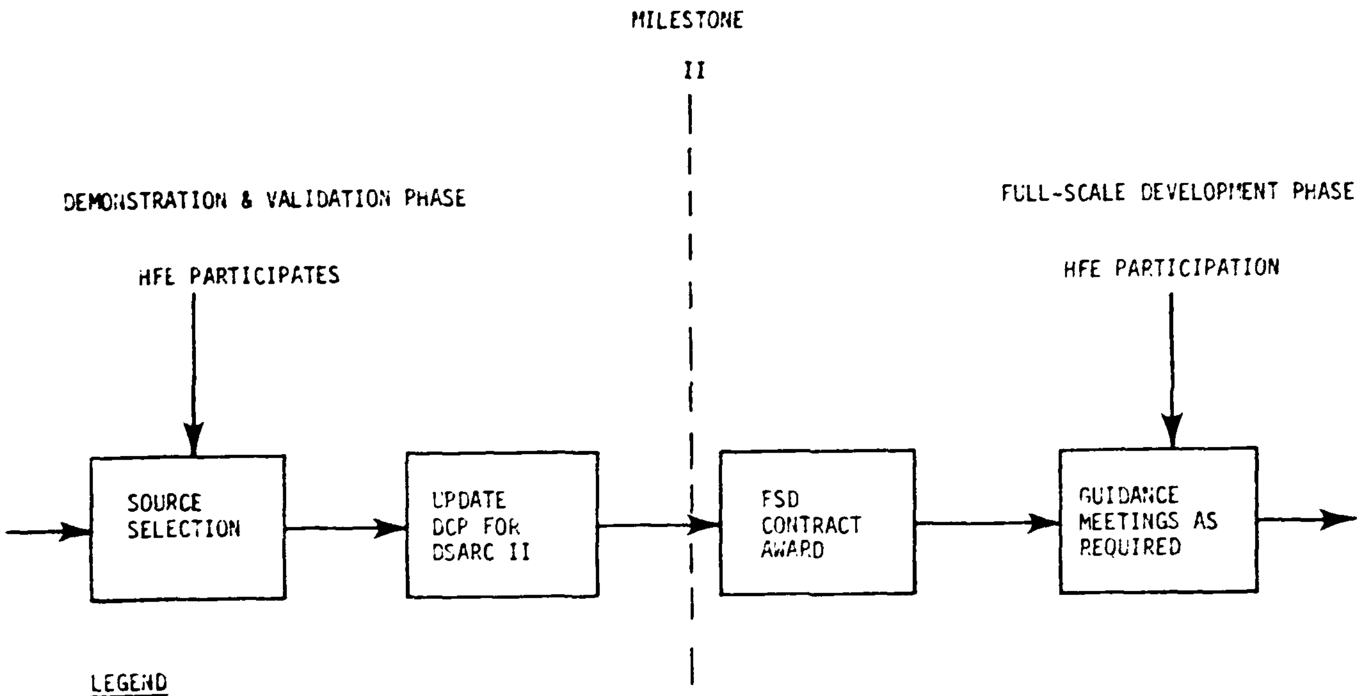
DEMONSTRATION & VALIDATION PHASE



LEGEND

HFE - HUMAN FACTORS ENGINEERING
SOW - STATEMENT OF WORK
RFP - REQUEST FOR PROPOSAL
SSE - SOURCE SELECTION EVALUATION

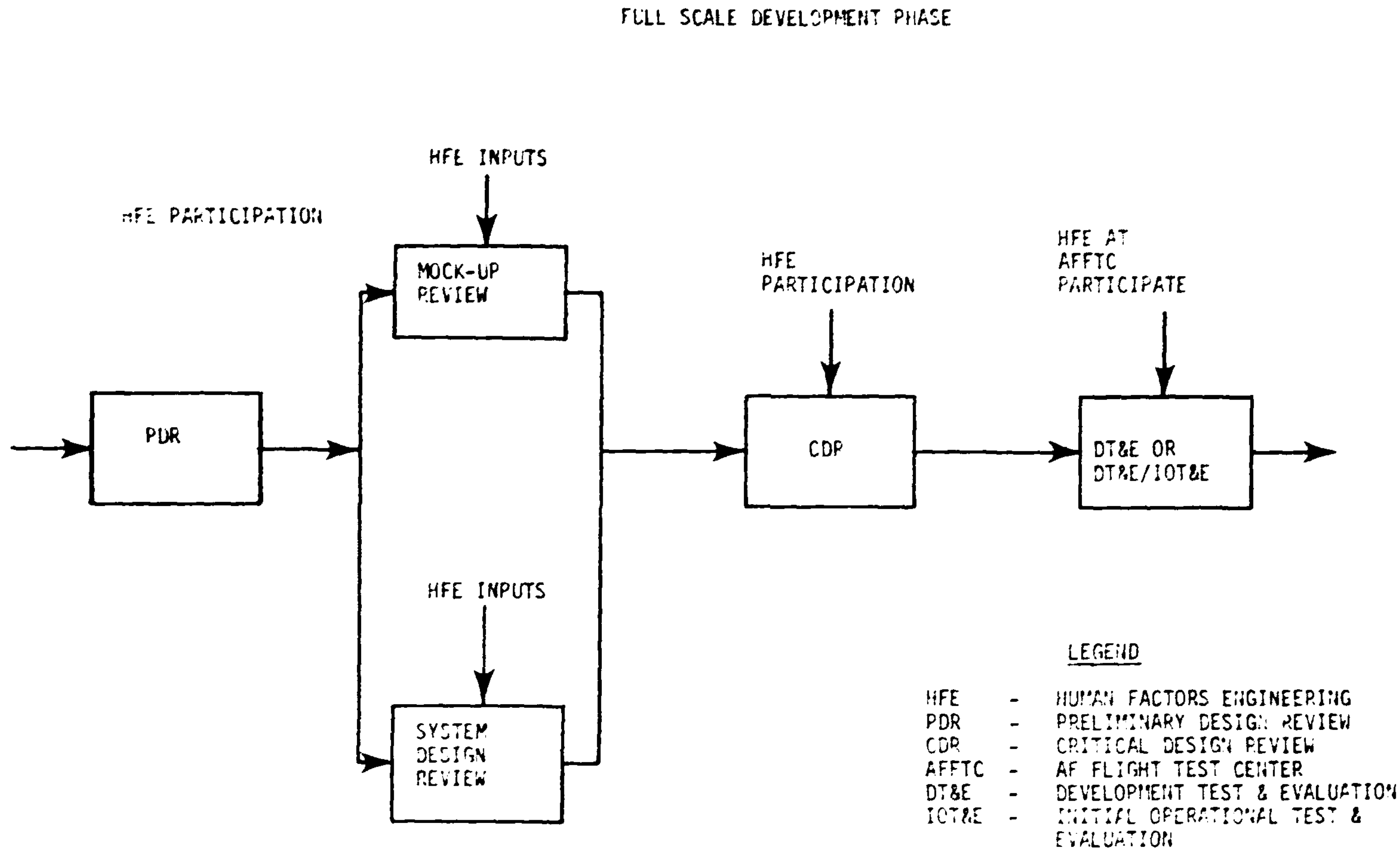
Figure 14. (Continued)



LEGEND

DCP - DECISION COORDINATION PAPER
DSARC - DEFENSE SYSTEM ACQUISITION REVIEW COUNCIL
HFE - HUMAN FACTORS ENGINEER

Figure 14. (Continued)



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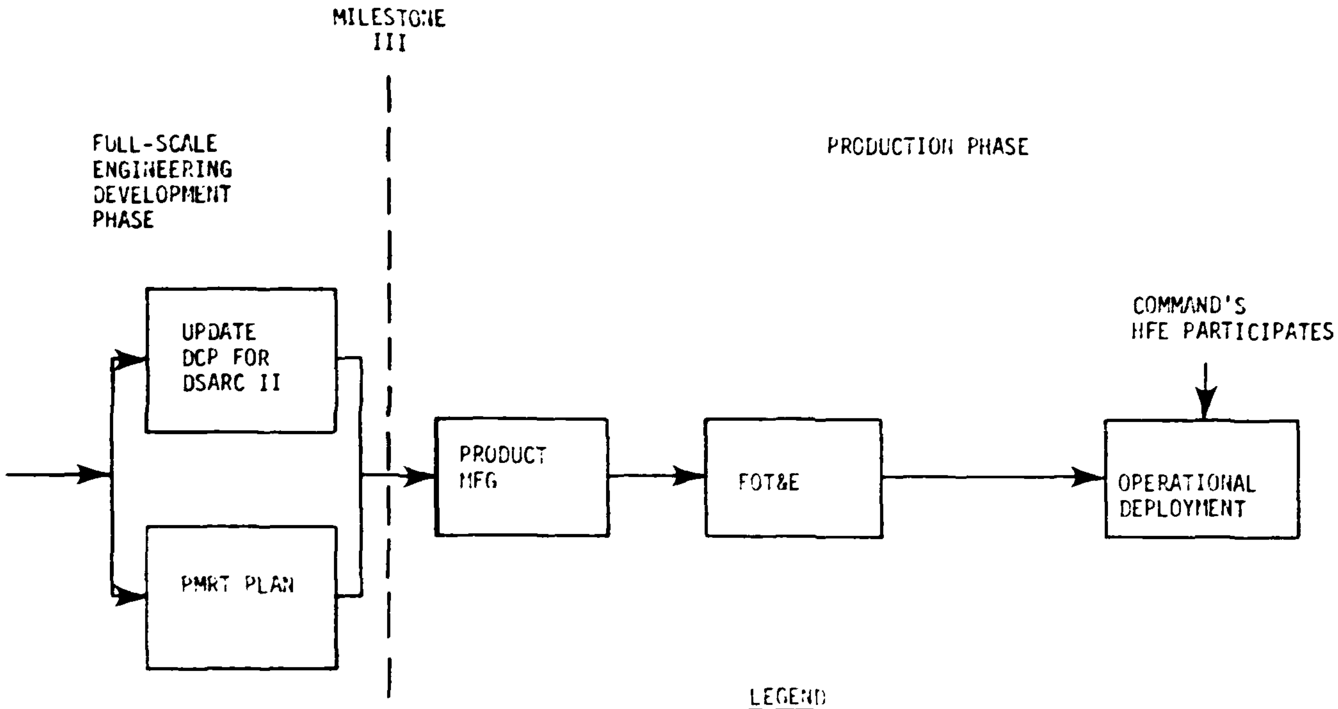

LEGEND

DSARC - DEFENSE SYSTEM ACQUISITION REVIEW COUNCIL
PMRT - PROGRAM MANAGEMENT RESPONSIBILITY TRANSFER
MFG - MANUFACTURER
FOT&E - FOLLOW-ON TEST AND EVALUATION

Figure 14. (Continued)

specializing in simulation research with AFHRL are also available. Engineering psychologists of the Human Engineering Laboratory of Aerospace Medical Division are likewise available to provide guidance and research support directly to the SPO. Personnel located at the contractor's fabrication facility are assigned to the Air Force Plant Representative Office (AFPRO) or to the Defense Contract Administrative Services (DCAS). They may be called upon by the Acquisition Manger to monitor progress directly, especially in suspected problem areas so as to assure equipment quality and to meet required delivery time schedules.

3. Air Force Documentation. The maintenance training equipment acquisition team headed by the SPO Acquisition Manager has documentary resources to assist in the translation of training equipment requirements into hardware specifications. Military Standard 490, "Specification Practices" contains 15 appendixes outlining appropriate types of specifications. AFHRL-TR-78-28, see Bibliography, pages 30 and 31 (Hannaman, Freeble, & Miller, 1978), gives the details of a two-part specification process normally employed in the acquisition of training equipment. The first part is the "Prime Item Development Specification" and the second part is the "Prime Item Product Fabrication Specification."

4. Contracting Procedures. AFHRL-TR-78-28 accurately states that the SPO responsibility for development of the specifications is usually accomplished through a contractor. The Prime Item Development Specification is usually prepared by the prime weapon system contractor from the documented training equipment requirements in conjunction with ISD personnel, and with direction, advice, and approval of the SPO Training Equipment Acquisition Manager. Thus, at least for acquiring training equipment for new systems, the requirement in AFR 50-11, Training, Management and Utilization of Training Devices, that ISD personnel be included in source selections is superseded at an earlier point in time by the weapon system source selection.

Acquisition Management

The weapon system contractor's responsibilities in preparation of the Prime Item Development Specification for maintenance training equipment are usually established at system source selection. This decision has customarily been made because the contractor has ready access to the necessary engineering data and expertise.

In most SPO maintenance training equipment acquisiton programs, a departure from the process prescribed by directives often occurs at the point when the Prime Item Development Specification for the weapon system is approved. Most often, as previously described, the prime weapon system contractor is awarded training equipment delivery responsibility.

The problem causing the change in the acquisition process, as stated by regulations, occurs because the prime contractor usually subcontracts the training equipment development and production effort. Armed Services procurement policy discourages technical inputs to the subcontracted process by Air Force monitors. Direction of this type may give the prime contractor reasons to demand additional funding or a modification of critical delivery schedules. Additional conflicts occur since regulations require the acquisition manager and team to maintain visibility and control throughout the development and production programs.

Usually, the Intercontinental Ballistic Missile (ICBM) SPO of Space and Missile Systems Organization(SAMSO)contracts with the weapon system contractor for training equipment and simulators. This contractor does not subcontract. Therefore, the ICBM SPO does not encounter the problem of maintaining program control and visibility.

In other instances when the ICBM SPO contracts directly for training equipment from other than the weapon system contractor, the management problems noted above are lessened by contracting for an engineering source data package called System Requirements Analysis, (SRA) from the prime contractor.

The SRA package supplied by the prime weapon system contractor is defined in SAMSO-STD-77-6 as "A sequential and iterative engineering process designed to establish the functional requirements for each element of a weapon system. The process provides a logical sequence and a clear record of the development of system requirements to manage the system engineering effort throughout all phases of system acquisition." This analysis systematically establishes requirements for equipment, personnel, procedures, and facilities. Figure 15 indicates SRA inputs to personnel and training development processes.

Engineering data and support from weapon system contractors for aircraft and electronic system SPOs are often variable in quality. Frequently they are not available in time to meet training definition requirements.

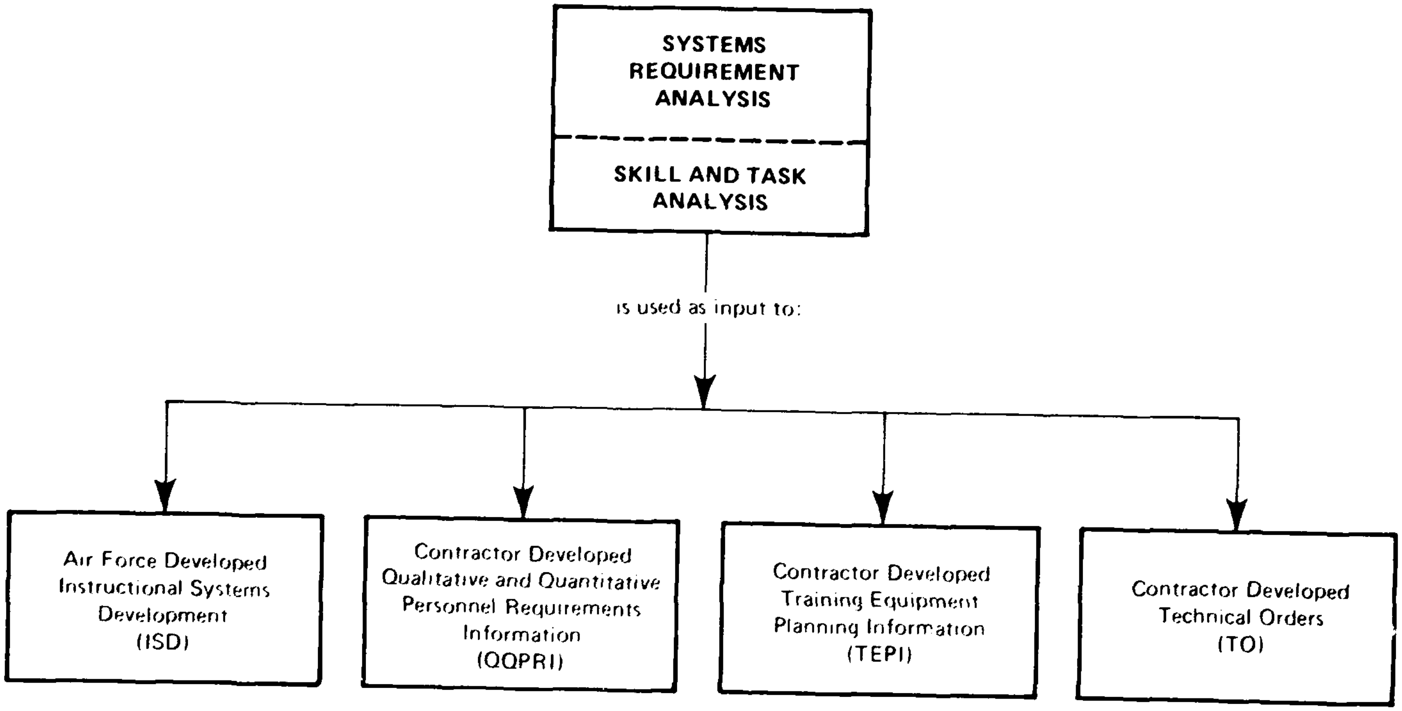

Figure 15. Systems Requirement Analysis (SRA) Documentation and the Processes They Support

The apparent critical differences between the SRA approach and that followed for aircraft weapon system contractors are:

1. The SRA data package has its own detailed and explicit specification, rather than being an associated output from the weapon system prime item specification.

2. Data production milestones and quality are closely monitored during production.

3. Data outputs are phased with weapon system development so that updated and expanded packages are produced as the system(s) are designed. In this way, preliminary data are released early, with more detail evolving as development progresses.

Other maintenance training equipment management differences among SPOs are caused by varying degrees of participation by engineering specialists in the decision-making process that supports the SPO Acquisition Manager. Engineer availability, personnel expertise level, and the SPO's willingness to consult the engineers are additional factors which affect decisions.

A Training Equipment Acquisition Process Model

The managerial decisions involved in the SPO training equipment acquisition process are identified and sequenced in the model that follows. In an attempt to accommodate the wide range of existing contractual, organizational, and managerial differences noted above, the model is necessarily very general. It is, however, applicable to most acquisition procedures. The decisions required in this process are indicated irrespective of the agency who may make them, whether it be the SPO Manager, a contractor, Air Force engineers, or an acquisition team.

The training equipment acquisition process model begins with training equipment design documents produced by the ISD team. Application of the recommended ISD procedures and the employment of the training equipment design process model proposed earlier structure the SPO inputs. Even efficiently managed acquisition effort may be wasted if the procured equipment has been based on an incomplete design process.

The major parts of the SPO acquisition decision process include the development of an effective procurement specification, the management of the development and fabrication process, and the evaluation of the delivered trainer.

A Procedural/Decision Sequence

Figure 16 depicts the procedural/decision process and summarizes the supporting inputs necessary for accomplishment. The major steps of the sequence involve:

1. Validate the training equipment function and design characteristics documented as a result of the ISD process.

2. Determine the feasibility of the validated equipment requirements in terms of available monetary resource estimates, delivery time requirements, and engineering state-of-the-art.

3. Present justification rationale to the SPO Program Director for approval of need and allocations.

4. Prepare Statement of Work (SOW) and Request for Proposal (RFP) documentation detailing the management approach applicable to contractor activities.

5. Select contractual source by comparatively assessing proposals on the basis of documented technical approach, understanding of requirements, innovations toward satisfying goals, timely product delivery, experience, facilities, personnel resources, and cost.

6. Reevaluate and finalize details of the procurement specification to assure concurrence with every specific requirement, emphasizing to the contractor that the rigorous test, acceptance, and checkout procedures contained in the specification will be strictly enforced.

7. Monitor, within contractually legal bounds, the developmental and production process to assure equipment and timeliness of equipment delivery.

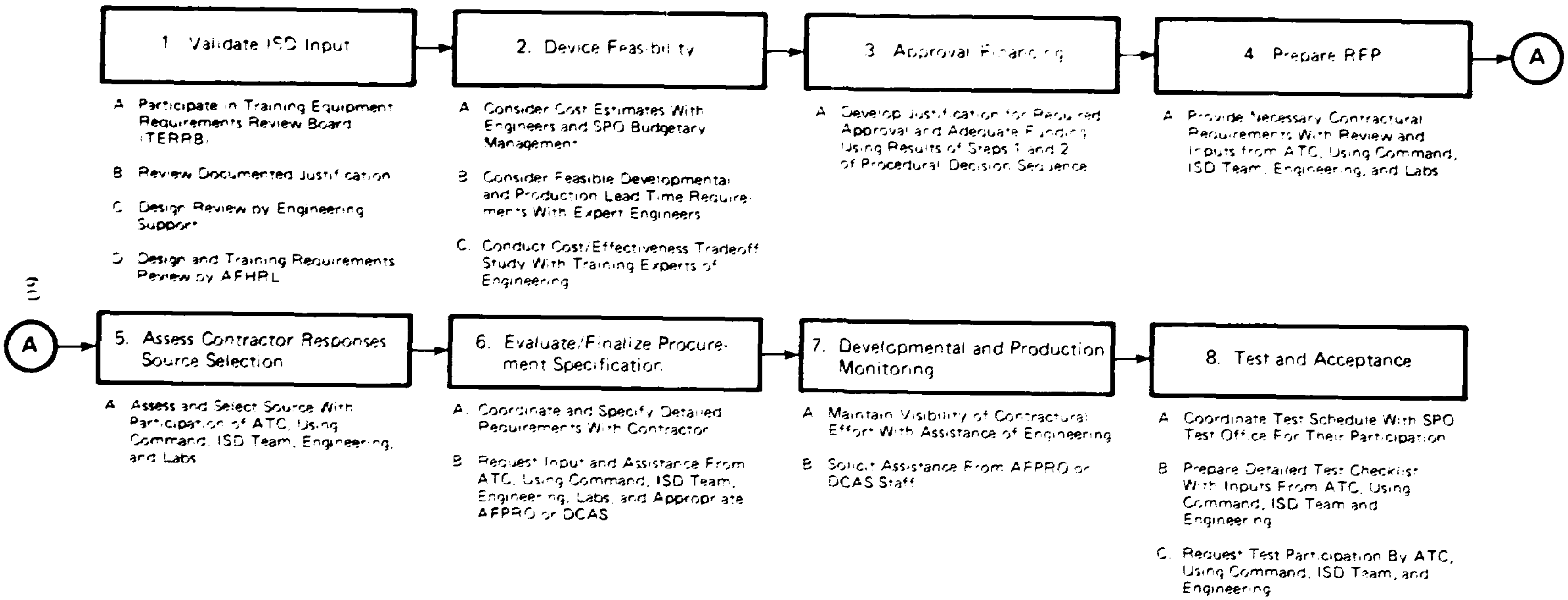

Figure 16. Maintenance Training Equipment Acquisition Procedural/Decision Sequence

8. Supervise and participate in the specified test, acceptance, and checkout activities. Coordinate using command and expert engineering support to assure that the maintenance training equipment meets contracted requirements.

Major Problems Areas

As a result of the review of documentation, the observations of SPO procedures and a study of the training equipment acquisition decisions required, three problem areas have been identified:

1. Variable Management Practices.

2. Lack of Procedural Guidance.

3. Late Acquisition.

Variable Management Practices

The variability of contractual organizational and managerial characteristics of the acquisition process often reflect a relatively low priority that maintenance training equipment has in comparison to other areas of the system development process. Lack of consistent organization among SPOs has resulted in varying degrees of program support to maintenance training equipment management and, subsequently, to variable training equipment quality.

The single point procurement management approach employed by SAMSO has recently been implemented for aeronautical systems. SIMSPO has been designated to assume this responsibility. This organization has extensive experience in managing the acquisition of flight crew simulators. This experience should effectively generalize to maintenance training simulators.

The major advantages of having all maintenance training simulators acquired through SIMSPO include:

1. Standardization of contracting procedures that establish a set of working arrangements with contracting officers and between team members of SIMSPO.

2. Utilization of its own cadre of maintenance simulator experts to deal with decisions requiring human factors and engineering expertise.

3. Coordinated channels with Air Force laboratory and engineering experts who, at times, may be needed to establish specifications and/or evaluation designs.

Lack of Procedural Guidance

A primary directive in the acquisition of maintenance training equipment is MIL-T-81821, Military Specification: Trainers, Maintenance, Equipment and Services, General Specifications For. This specification, in the opinion of the authors, appears to place requirements for realism and functional fidelity which can adversely affect the ultimate cost-effectiveness of maintenance trainers, especially simulators. The directive also necessitates extensive justification effort if the requirements are deviated from to achieve enhanced instructional value.

Under conditions where maintenance simulators are being procured through the weapon system SPO, this directive is particularly cumbersome. Many Training Equipment Acquisition Managers are new to their jobs and are relatively unfamiliar with maintenance training and with equipment procurement. For them, MIL-T-81821 can be especially misleading in guiding the preparation of procurement specifications.

With the shift of acquisition responsibility for maintenance simulators to SIMSPO the detrimental effects of MIL-T-81821 will be reduced. Highly experienced specification writers will be able to selectively apply the requirements to achieve the training effectiveness identified and recommended by the ISD analysts. On-going studies of maintenance training equipment design and acquisition should produce the principals and procedures to permit future updating of MIL-T-81821.

Late Acquisition

The most important problem area in the acquisition process is that the definition of training equipment requirements and the subsequent issuance of a procurement specification are not accomplished in time to permit trainer delivery in support of initial operational training. There are several related factors involved. Late receipt and lack of completeness of engineering and task data provided to the ISD teams prolongs the equipment design period.

1. A staff study conducted and reported by Aeronautical Systems Division recommends centralized procurement of maintenance simulators for aircraft systems in ASD's Simulator SPO (SIMSPO).

A paragraph of the study states: "...the major funding problem was the need for using training equipment funds to cover overruns in the air vehicle system." (Maintenance Training Simulator Procurement, page 8). Earlier training equipment requirement definition could have provided contractual utilization of budgeted funds before they were used for other purposes.

2. The late definition of requirements sometimes results in a contract which combines research/-development and fabrication phases. These procurement practices occur in an effort to meet required equipment delivery dates by attempting to make up time lost in defining requirements. This type of contract often results in funding difficulty due to an escalation of device complexity and price.

   In addition, there are times when insufficient manpower availability among engineering advisors whose time is shared among acquisition programs of several systems delays completion of the specification. Finally, high turnover rates among SPO Acquisition Managers during the procurement process due to military transfers further slows the procurement process and detracts from the availability and cost-effectiveness of the final training system.

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